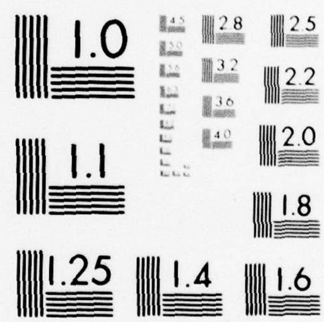
AD-A074 536 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 13/2
APPLICATION OF MAPS TO THE SALINAS-MONTEREY URBAN STUDY.(U)
AUG 79 T M WALSKI, A C GIBSON
UNCLASSIFIED WES/EL-79-4 NL

1 OF 2
AD
A074536



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

(2) LEVEL II

M. P. EL-79-4

APPLICATION OF MAPS TO THE SALINAS-MONTEREY URBAN ST

AD A074536

MISCELLANEOUS PAPER EL-79-4

See also Appendices B, F and G A074543

APPLICATION OF MAPS TO THE SALINAS-MONTEREY URBAN STUDY

by

Thomas M. Walski, Anthony C. Gibson

Environmental Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

August 1979

Final Report

Approved For Public Release; Distribution Unlimited

Prepared for Office, Chief of Engineers, U. S. Army
Washington, D. C. 20314

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper EL-79-4	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 APPLICATION OF MAPS TO THE SALINAS-MONTEREY URBAN STUDY.		5. TYPE OF REPORT & PERIOD COVERED 9 Final report,
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Thomas M. Walski Anthony C. Gibson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Environmental Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Wastewater Management Program 31542
11. CONTROLLING OFFICE NAME AND ADDRESS Office, Chief of Engineers, U. S. Army Washington, D. C. 20314		12. REPORT DATE 11 August 1979
		13. NUMBER OF PAGES 124
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) 12 129		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

14 WES/EL-79-4

D D C
RECEIVED
OCT 2 1979
B

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Appendices B, F, and G were reproduced separately in limited number since they contain large amounts of data that would be too detailed for most readers of this report. ~~They can be obtained by contacting the authors.~~

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Costs
MAPS (Computer program)
Monterey County, Calif.
Planning
Santa Cruz County, Calif.
Water supply

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The MAPS (Methodology for Areawide Planning Studies) computer program, developed at the U. S. Army Engineer Waterways Experiment Station (WES), was used to evaluate the engineering aspects of alternative water supply plans for the Salinas-Monterey Urban Study conducted by the U. S. Army Engineer District, San Francisco. Using MAPS, the WES study team identified feasible water supply plans, developed staging for required facilities, and calculated capital and operation and maintenance costs for these facilities. The two (Continued)

Cont

DD FORM 1473 1 JAN 73 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

411 388 LB

20. ABSTRACT (Continued)

Cont'

counties in the study area, Santa Cruz and Monterey, were faced with different water supply problems, which were addressed using slightly different techniques, presented in the following paragraphs.

In Santa Cruz County (except for the lower Pajaro area), water supply problems consisted chiefly of providing municipal water from an integrated system of surface and groundwater sources. MAPS simulations were used to identify potential diversions and reservoir sites to meet future needs. Source development was staged through the year 2020. Given three sets of population projections, Santa Cruz County was divided into three subareas for the purpose of the study - San Lorenzo, Aptos-Soquel, and Pajaro. Forty feasible alternative plans were identified and staged for these areas, alone and in regional systems. The WES study team then identified the required facilities and prepared schematic diagrams of the plans. MAPS was then used to calculate the capital and operation and maintenance costs of each of the facilities. The equivalent annual cost of each facility as a function of the year built was developed and the equivalent annual cost of each plan (under the base population projection) was determined. Methods for determining the equivalent annual costs for different population projections or water usage (e.g., conservation) are presented in the report.

In Monterey County, irrigation represents the principal use of water, which is derived almost solely from wells. The U. S. Geological Survey developed a finite element groundwater model to identify the effect of different water use rates on the groundwater resources. From this study, six measures for storing and transporting water were identified. These measures were divided into the required facilities by the WES study team, which developed preliminary design and cost estimates using MAPS. Since the staging of the measures is not tied to population projections, the equivalent annual cost was calculated as a function of time so that economic analysis could be conducted for any year of construction.

PREFACE

This report was prepared (a) to supplement the detail of the water supply alternatives presented to local decision makers as part of the Salinas-Monterey Urban Water Resources Study, and (b) to illustrate the application of the Methodology for Areawide Planning Studies (MAPS). This study represents the first application of MAPS to a Corps planning study.

Development of MAPS was funded under the Wastewater Management Program Work Unit 31542, for the Urban Studies Branch of the Office, Chief of Engineers (DAEN-CWE-BU). This report was prepared for the Office, Chief of Engineers, by Dr. Thomas M. Walski, sanitary engineer, and Mr. Anthony C. Gibson, mathematician, of the Water Resources Engineering Group (WREG), Environmental Engineering Division (EED), Environmental Laboratory (EL) at the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. Technical assistance and review were provided by Dr. Eugene R. Perrier, WREG, Drs. Marion W. Corey and James W. Epps of Mississippi State University, and COL Charles K. Fellows, CE, who is also a Senior Engineer for the California Department of Water Resources.

Drafting and typing were provided by Mrs. Jean M. Bishop, Mr. Donald F. Hayes, Mrs. Cheryl M. Lloyd, and Mrs. Patricia B. Hopkins of the WREG. Chief of the WREG was Dr. Raymond L. Montgomery; Chief of the EED was Mr. Andrew J. Green; and Chief of the EL was Dr. John Harrison.

A great deal of information contained in this report was provided by Mr. Ben Wells, Study Coordinator of the Salinas-Monterey Urban Study, and Mr. Mort Morkowitz of the Hydrology and Hydraulics Section, both of the U. S. Army Engineer District, San Francisco.

Commanders and Directors of the WES during preparation of this report were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

---

* Appendices B, F, and G were reproduced separately in limited number since they contain large amounts of data that would be too detailed for most readers of this report. [redacted]

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
acres	4046.856	square metres
acre-feet	1233.482	cubic metres
acre-feet per year	0.00003908365	cubic metres per second
cubic feet per second	0.0283	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	cubic metres per second
gallons per day	0.00000004381	cubic metres per second
horsepower (electric)	746	watts
inches	2.54	centimetres
inches per year	0.00000008048162	centimetres per second
kilowatt-hour	3600000	joule
miles (U. S. statute)	1.609344	kilometres
million gallons per day	0.04381	cubic metres per second
square feet per second	0.09290304	square metres per second
square miles (U. S. statute)	2.589988×10^6	square metres

APPLICATION OF MAPS TO THE SALINAS-MONTEREY URBAN STUDY

PART I: INTRODUCTION

1. The Salinas-Monterey Bay Area Urban Water Resources and Wastewater Management Study (hereafter referred to as the "Urban Study") was prepared by the San Francisco District (SFD), South Pacific Division, U. S. Army Corps of Engineers. The objective of the Urban Study as stated in the Plan of Study[1] was "to develop, with continuous effective participation from the public concerned, a range of feasible water resources and wastewater management alternatives that are specifically oriented to meet the needs of an urban area." To assist in this type of planning work, the Environmental Laboratory (EL) of the U. S. Army Engineer Waterways Experiment Station (WES) has prepared the Methodology for Areawide Planning Studies (MAPS) computer program which can be used to evaluate alternative areawide plans. This report describes the use of MAPS in the Salinas-Monterey Urban Study. The objective of the application of MAPS is to produce a set of feasible water supply alternative plans for the study area and to determine the costs of these plans.

Purpose and Scope

2. The MAPS program was used as the principal tool in one of three studies conducted in the water supply task of the Urban Study. The U. S. Geological Survey (USGS) developed a finite element model to study groundwater hydrology in the Salinas Valley in Monterey County.[2] By using the model for alternative pumping and recharge schemes, the USGS was able to determine the impacts of the alternative schemes on the groundwater. The cost of these alternatives was evaluated using MAPS. In Santa Cruz County, MAPS was used to evaluate the adequacy of reservoir systems; identify, size, and stage required reservoirs, pipelines, and treatment facilities; and calculate the capital, operation, maintenance, and average annual costs of these needed facilities.

3. The output from the MAPS program and the USGS finite element program, plus information developed during earlier studies, was used by Earth Metrics, Inc.,[3] in preparation of the final Stage 2 Water Supply Study, Alternative Water Supply Plans for Monterey and Santa Cruz Counties. In this report, the results of the previous studies were presented in the format described in the Engineer Regulation ER 1105-2-200 series.[4]

4. MAPS was used in the Salinas-Monterey Urban Study to formulate and evaluate alternative Stage 2 water supply plans. Four progress reports were provided by WES during this investigation. The first, called the "Progress Report" (December 1977), contained background data and described the study procedure. The second, "Development of Stage 2 Alternatives" (February 1978), contained a description of feasible plans to meet water demand through 2020 for Santa Cruz County. The third, "Cost of Water Supply Facilities in Santa Cruz County" (April 1978), contained design and cost information for feasible plans. The fourth, "Design and Cost Information for Monterey County" (May 1978), contained preliminary designs and costs of the required facilities which were part of the measures identified by the SFD to meet water supply needs in Monterey County. This report combines all four reports into a single comprehensive report.

5. This report contains the results of work performed during the second stage of what was intended to be a three-stage study. Some issues such as recharge of groundwater and design of San Felipe pipeline were to be addressed in Stage 3 of the study which has since been cancelled after this report was first written. These issues should be studied in more detail before the plans are implemented.

6. MAPS was applied to the Salinas-Monterey Urban Study by the program developers at WES with assistance from SFD personnel. The principal advantage in using MAPS was that it allowed a very large number of alternative plans to be formulated and evaluated in a short time frame. In Monterey County, where MAPS was used only to develop costs of possible facilities, six water supply measures were developed and costed. These included reservoirs, canals, wellfields, pump stations,

force mains, and tunnels.

7. In Santa Cruz County, where MAPS was also used to simulate the effects of alternative plans, 40 feasible plans were developed for all or part of the county out of an even larger number that were screened. Using MAPS, the county was divided into roughly 100 links and nodes and the network was simulated for the study period from 1978 to 2020 at 10-year time increments for a design dry cycle lasting 30 months, using 3 population projections. Included in these simulations were 20 streams, 15 reservoirs, 18 major transmission systems, and 10 treatment facilities. Preliminary design and cost estimates with staging of facility construction were developed for each of the storage, treatment, and transmission facilities required. It would have been extremely costly and time-consuming to develop the many alternative plans in the detail shown in this report without MAPS.

Description of MAPS

8. MAPS is a computer-based set of models developed by the EL to serve as a tool for planners and engineers in the development and evaluation of alternative water supply and wastewater management plans. Although developed to assist in plan evaluation for the Corps' Urban Studies Program, MAPS can be used effectively in most water supply and wastewater studies

9. MAPS consists of a number of stand-alone programs encompassed under one framework. Programs or modules provide preliminary design and cost for water supply and wastewater management system components. MAPS modules used for facilities in this study included pump stations, wellfields, reservoirs, water supply treatment plants, wastewater treatment plants and water transmission systems including gravity, force mains, and open channels.

10. In addition to being used in examination of individual components, MAPS was used to simulate many water system networks by breaking them into a series of nodes (facilities and service areas) and links (transmission lines and streams). With these link-node networks, MAPS

was used to trace the transmission, treatment, storage, and consumption of water throughout the study area for an array of alternative plans and futures.

11. MAPS can be used in both Stage 2 and Stage 3 plan evaluation steps. The three stages evaluation are described in Engineer Regulation ER 1105-2-200.[4] This computer-based model provides a quick method for carrying out the iterations and trade-off analyses required by the regulations. MAPS is well suited for building up the plans from the broad Stage 2 alternatives to the more detailed Stage 3 evaluations. In this application, it was used in the Stage 2 water supply task.

12. New modules and other capabilities can be added depending on the needs of Corps Districts. The modular nature of this model makes it easy to accommodate new features. Similarly, program users have the option of using only those features of the model that will be helpful in their study.

PART II: BACKGROUND OF THE URBAN STUDY

13. The purpose of the Urban Study was to solve a wide range of water resource problems in the Salinas-Monterey Bay area. While this report deals with alternative solutions to water supply problems, the Urban Study addressed a variety of water resource issues including water quality, wastewater management, recreation, flood control, beach and shoreline erosion, and navigation.

Description of Urban Study Area

14. The study area occupies approximately 6440 square miles* in the immediate vicinity of Monterey Bay in central California. The study area consists principally of Monterey and Santa Cruz Counties although it also includes parts of San Benito, San Luis Obispo, San Mateo, and Santa Clara Counties.

15. For the purpose of the water supply study, it is more convenient to divide the study area according to hydrologic subbasins. These include Santa Cruz Coastal, San Lorenzo River, Aptos-Soquel Creek, Pajaro River, Salinas River, and Carmel River. The characteristics of the subbasins, as summarized below, are taken from the Urban Study's Plan of Study (POS):[1]

Subbasin	Acres	Square Miles	% of Total Study Area
1. Santa Cruz Coastal	96,000	149.0	2.3
2. San Lorenzo River	87,104	136.1	2.2
3. Aptos-Soquel Creek	49,000	77.0	1.2
4. Pajaro River	833,280	1,300.0	20.1
5. Salinas River	2,840,000	4,450.0	69.2
6. Carmel River	204,000	320.0	5.0
TOTAL	4,109,384	6,432.1	100.0

* A table of factors for converting U. S. customary units of measurement to metric (SI) can be found on page 4.

The subbasins are shown in Figure 1 and are discussed in more detail in the following paragraphs.

16. The Santa Cruz Coastal subbasin consists of a number of small streams which drain into the Pacific Ocean northwest of the San Lorenzo River and south of Pescadero Point. Of these streams, Laguna, Lidell, and Majors Creeks are currently being used for water supply to Santa Cruz. Sites for diversions or reservoirs exist on Baldwin, San Vicente, Scott, and Waddell Creeks. Flow in these streams is generally not very reliable; i.e., they are often dry during parts of the year. Available groundwater supplies in the area are also limited.

17. The San Lorenzo River subbasin lies entirely in Santa Cruz County. There are a large number of diversions for water supply, the most notable being at the City of Santa Cruz at (1) Graham Hill for the treatment plant located there, and (2) Felton for backpumping to Loch Lomond Reservoir. Loch Lomond Reservoir, located on Newell Creek, is the only major reservoir in the San Lorenzo Basin. The San Lorenzo Valley is too densely developed to serve as a reservoir site except for a site far upstream at Waterman Switch. However, a large number of sites on the tributary creeks exist, including Bear, Boulder, Kings, and Zayante Creeks. At the Zayante Creek site, a scheme to pump water from the San Lorenzo River is also feasible. Some groundwater supplies also exist in the valley. Urbanization is limited to coastal areas and river valleys.

18. Aptos and Soquel Creeks drain approximately 77 square miles between the San Lorenzo and Pajaro River Valleys. While there are no reservoirs in this subbasin, two good sites exist in the upper reaches of Soquel Creek. Aptos Creek flows through Nicene State Park which will make reservoir construction unlikely although direct diversions can be made. Urbanization in this subbasin is restricted to coastal areas. A significant groundwater basin underlies the Soquel Valley.

19. The Pajaro River drains approximately 1,300 square miles in central California. There are two major reservoirs (Uvas and Chesbro) and the urban complex of Morgan Hill-Gilroy above Pajaro Gap. Much of the water use in this area is for agricultural purposes. The area of primary interest for the Urban Study is the City of Watsonville and the

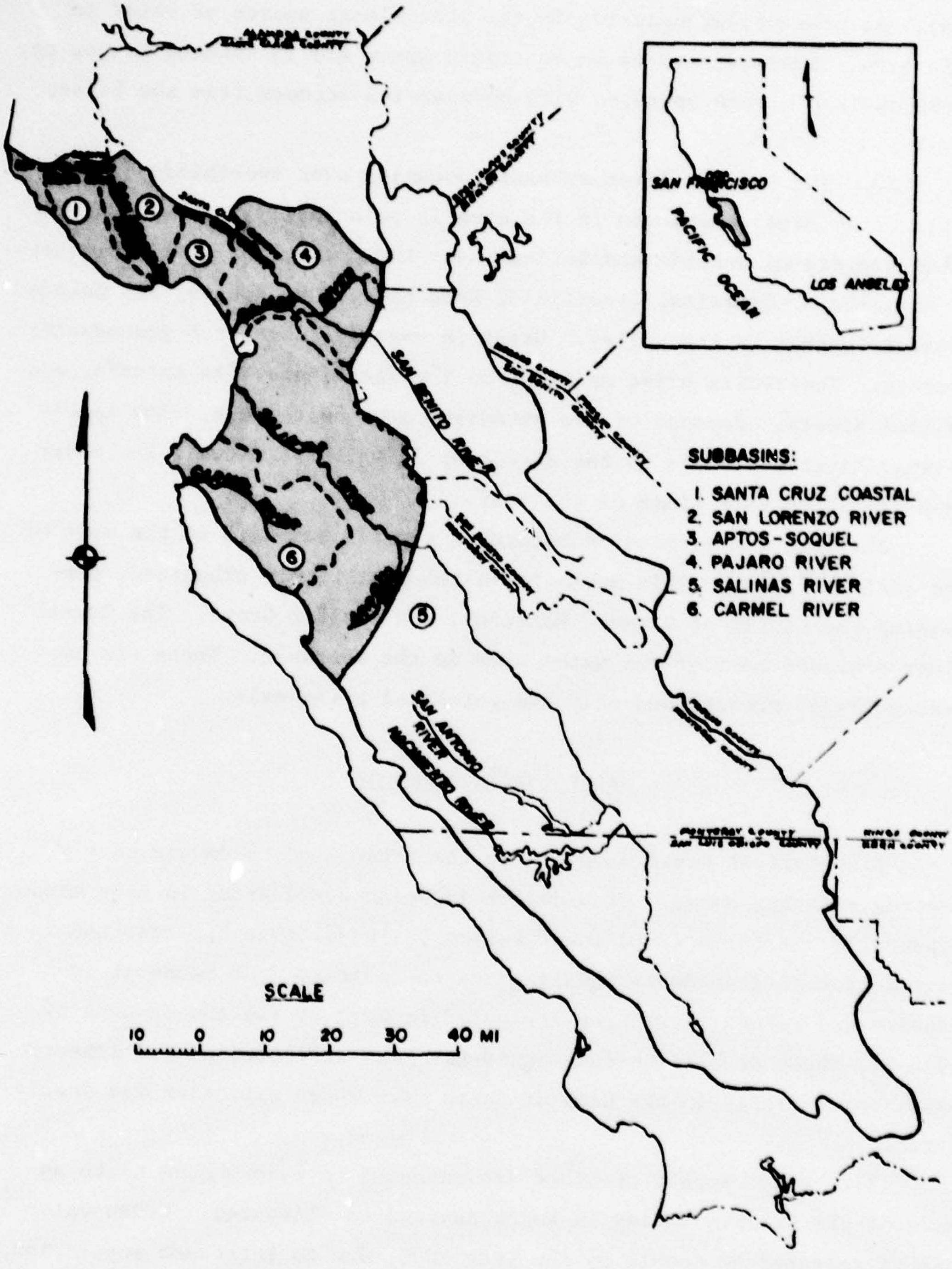


Figure 1. Salinas-Monterey Bay Area Urban Water Resources and Wastewater Management Study

lower Pajaro Valley (that portion of the Pajaro Valley below Pajaro Gap). At present, groundwater is the predominant source of water in this area. Reservoir sites on Pescadero Creek and in Corncob Canyon may prove desirable when operated with backpumping schemes from the Pajaro River.

20. The Salinas River subbasin occupies over two-thirds of the Urban Study area. Land use in the area is principally agricultural with urban centers of Seaside and Salinas near the coast, and smaller centers at Atascadero, Gonzales, Greenfield, King City, Paso Robles, and Soledad located further up the valley. Water is usually taken from groundwater sources. Reservoirs exist upstream on the Nacimiento, San Antonio, and Salinas Rivers. Because of the extensive groundwater use, flow in the Salinas River decreases in the direction in which it flows. The river runs dry at certain times of the year.

21. The Carmel River subbasin is a small subbasin to the west of the Salinas Valley. This subbasin is the most highly urbanized, containing the cities of Carmel, Monterey, and Pacific Grove. The Carmel River provides most of the water used in the subbasin. There are no reservoirs at present and only two potential sites exist.

Water Supply Problems

22. Current water supplies in the Urban Study area are barely meeting existing needs. Groundwater is being overdrafted in many areas, especially the Salinas and lower Pajaro Valleys. This has resulted in a degradation of groundwater quality due to salinity from seawater intrusion and return flows from irrigated lands. During the drought of 1975-77, these problems became acute for both agricultural and domestic uses, particularly in the City of Santa Cruz where rationing was instituted.

23. Water supply problems are expected to become more acute as more of the Salinas Valley is being devoted to vineyards. Urban water use is expected to double by the year 2000, due to increased population. This is especially true in the Monterey Peninsula.

Water Supply Objectives

24. According to the POS,[1] the goal of the water supply task is to "determine future water supply demands and evaluate alternative sources for meeting these demands through utilization of groundwater, surface water, reclaimed water and imported water for the Santa Cruz Coastal, Aptos-Soquel, San Lorenzo, lower Pajaro, Carmel and lower Salinas subbasins within the Study Area."

25. Since groundwater sources are generally being exploited to their capacity, little potential exists for further development of this resource. The two sources investigated in most detail in this report are impoundments on surface streams and importing water from outside the Urban Study area.

26. Impoundments are important in this area since rainfall is not evenly distributed in time. For example, in the San Lorenzo River, 60 percent of the annual discharge occurs between January and March. Impoundments can store these high flows for use in the dry months. The capacity of the impoundments is limited by the fact that the best sites are located far upstream with very limited drainage areas. Santa Cruz County also has the option to purchase water from the Bureau of Reclamation's San Felipe Project.

27. Recharge of groundwater with treated wastewater and conservation of existing supplies through demand reduction can also help in alleviating future water supply problems. Development of alternative plans using the above measures to meet water needs under several alternative futures is presented in the following parts of this report.

PART III: DISCUSSION OF MAPS APPLICATION TO THE URBAN STUDY

28. This part of the report describes the steps used in applying the MAPS program to the Salinas-Monterey Urban Study. It summarizes the input data required and the manner in which these data were used to generate alternative plans. A more detailed discussion of simulations relevant to the Santa Cruz area (portions of Subbasins 1, 2, and 3) used in the MAPS analyses is presented in Part IV and in the Appendixes.

29. The Stage 2 Santa Cruz water supply evaluation served as a test case for the MAPS program. The alternatives presented herein were used to develop the detailed water supply plans for the final Stage 2 report of the Salinas-Monterey Urban Study.[3]

30. A large number of alternative water supply plans were investigated. In order to develop a precise scheme for identifying applicable alternatives, the alternatives were divided into categories depending upon the portion of the area considered. For this reason, the study area to be evaluated was divided into three parts (S, A, and P) as shown in Figure 2 and listed below:

Key Letter	Study Area
S	San Lorenzo Subarea Plans (including North Coast streams)
A	Aptos-Soquel Subarea Plans
P	Lower Pajaro River Subarea Plans
SA	Combined San Lorenzo and Aptos-Soquel Subarea Plans
SAP	Combined San Lorenzo County Plan

31. In Stage 2, MAPS is used to simulate the flows at various times in the streams and pipelines, pool elevations, and reservoirs for the alternative solutions to the design dry cycle. The input to MAPS is a description of the plan in terms of links and nodes which simulate the capacities of the facilities that make up the plan, the water required in the service areas, and the hydrology of the streams in the service area. Figures 3a-3d, located in Part IV, give the hydrologic network in

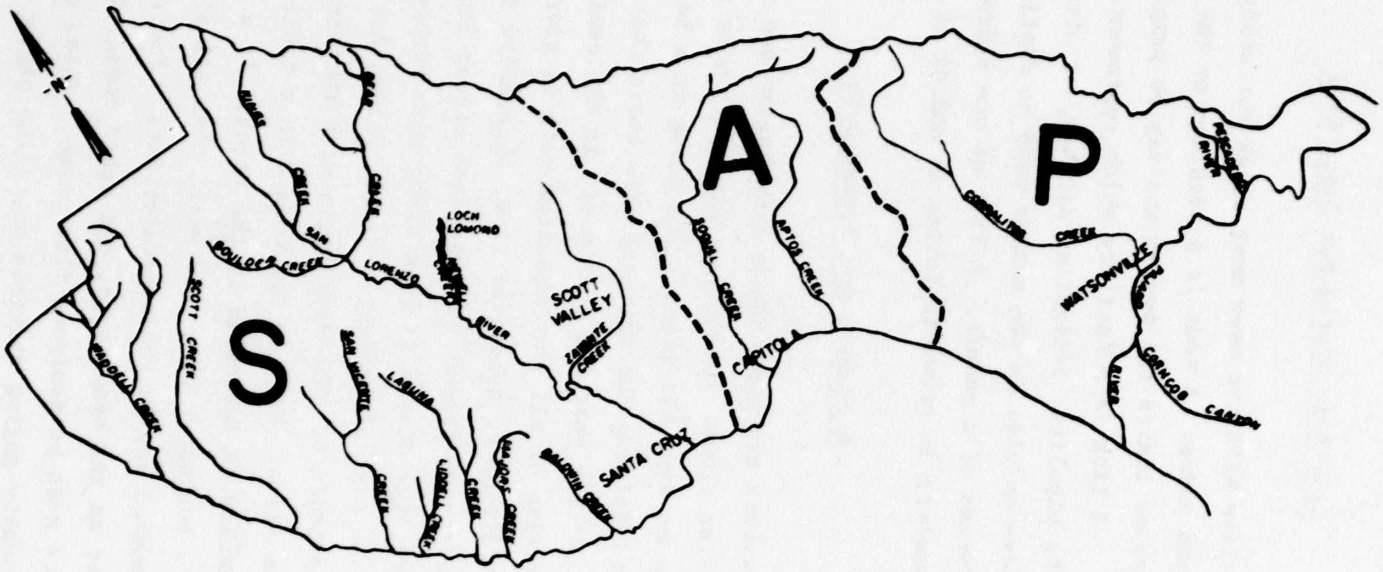


Figure 2. Subareas used in MAPS source analysis

terms of links and nodes.

Link-Node System for Santa Cruz

32. To utilize MAPS the user must break the study area into a system of links and nodes. A node is a location in the study area at which water enters or leaves the system and may be pumped, treated, consumed, or stored. A link is a facility which represents a method of conveying water by pipeline, irrigation ditches, or streams. A mod number of one of these modules is the number used to distinguish between different occurrences of a module. A list of the hydrologic nodes, links, and mod numbers is shown in Tables A1 and A2 of Appendix A.

Headwater and Stream Data

33. Headwaters are nodes where flow begins and streams are links through which water flows. In MAPS, a headwater node is a point on a stream most distant from the mouth. The flows at a headwater node are calculated by multiplying the drainage area above that node by the runoff rate in inches per year for that month in the design drought from the area. A listing of all the headwater data is given in Appendix B.

34. In addition to headwater flow, streamflow increases from runoff into the stream reaches because each stream link drains a given area. Therefore, the change in flow along each stream reach can be calculated as in the case of headwater flow. Values for each stream reach are given in Appendix C. The data begin with the stream's mod number followed by the title. Next in Appendix C is a table giving the amount by which streamflow is increased in the reach. If a stream represents the flow from a headwater to a reservoir, then all of the flow caused by runoff is accounted for in the headwater data. For each run, the origin node is defined as the headwaters, and other nodes with no flow into them from links must be assigned flow rates. These rates are based on the flows at nearby gaging stations or, if no gaging station exists, the rates must be estimated for runoff from the drainage area of the

headwater node. Thirty time periods of 30 days each, which represent the design dry cycle, were used for unsteady-state simulations. The design dry cycle of 900 days corresponds to the 1975-77 drought. These flows were used in sizing reservoirs and treatment and transmission facilities.

Hydrologic and Population Projection

35. Data for the MAPS simulation runs were taken primarily from the Creegan & D'Angelo-McCandless "Master Plan Development"[5] and the U. S. Geological Survey "Water Resources Data for California" (various years).[6] Considerable amounts of information needed for the MAPS simulation were supplied by personal communication with Ben Wells, Urban Study Coordinator, and Mark Markowitz, Hydrology and Hydraulics Branch, San Francisco District.

36. The design dry cycle as used in the MAPS runs is the period April 1975 to September 1977. The simulation was terminated in September 1977 because streamflow data in the study area were not available. Some problems resulted because the optimal reservoir size could not be accurately determined due to lack of data since flows into the reservoir were not recorded during the period in which the reservoirs were filling at the end of the drought. The reservoir sizes recommended in the "Master Plan Development" were used for the MAPS simulation. In the case of the extended drought (1975-1977), these sizes should not vary greatly from those reservoirs that were calculated earlier. The reservoir sizes are indicated in Table 1 in Part IV.

37. The Santa Cruz simulation was divided into six service areas for use in the MAPS simulation, five of which are shown in Appendix A, Table A3. A service area is a diverse group of water users concentrated in a relatively small area such as a town, city, or isolated industry. There are three sets of population projections for each service. They are:

a. EPAC low projection

b. EPAC base projection

c. EPAC high projection

These are based on projections made by the California Environmental Protection Agency (EPAC) and contain low, base, and high assumptions as to birth and migration rates. Note that the population given in Appendix A, Table A3, is the population served by the municipal system.

Water Sources

38. The water sources in the Santa Cruz area were divided into the following categories: surface water direct diversions, groundwater, imported water, treated water, and surface water storage.

Surface water direct diversions

39. During wet periods surface streams can provide a large share of the water required by these service areas. The Santa Cruz area has surface water direct diversions at Laguna Creek, Majors Creek, Liddell Creek, and the San Lorenzo River. The upper San Lorenzo Valley water suppliers have surface water direct diversions on the San Lorenzo River. Watsonville also diverts water from Corralitos Creek.

40. Additional surface water direct diversions can be made from a number of streams. Additional diversions could delay the time when the water stored in reservoirs is required in a dry period and could hasten the filling of reservoirs after a dry period. These additional diversions for Santa Cruz would be at San Vicente Creek, Scott Creek, and Waddell Creek; whereas for the Aptos-Soquel area, diversions would be from Aptos and Soquel Creeks. The average flow during the period of record for each stream* is summarized below:

Stream	Average Flow, cfs	Minimum Flow, cfs
Aptos	7.6	0.36
San Vicente	8.5	0.39
Scott	30.6	0.00
Soquel	42.7	0.10
Waddell	Ungaged	

* Note that 1 cfs is sufficient flow for approximately 4000 people - 162 gpd per capita.

41. While the existing surface water direct diversions and additional diversions would be adequate and inexpensive sources during wet periods, they would be virtually useless during dry periods. Most of the existing diversions (as summarized in paragraph 40) provided very little water during the design dry cycle; therefore, little if any additional water could have been obtained from these sources. Because of this, it was decided that additional surface water direct diversions would only be considered in cases where transmission lines crossed the streams (e.g., diversion at San Vicente if Scott Creek Dam is built).

Groundwater

42. Groundwater resources have been developed to varying degrees in different parts of the Santa Cruz area. The groundwater has been overexploited in the Watsonville area. In the Aptos-Soquel area, the wellfield capacity is comparable to the estimated available groundwater. In the San Lorenzo and North Coast areas, additional groundwater resources can be developed.

43. The existing yields for municipal and industrial water were calculated by summing existing groundwater capacities and are summarized below:

Area	Current Capacity mgd	Estimated Firm Yield, mgd
San Lorenzo Area	5	15
Aptos-Soquel Area	10	10
Pajaro Area	5	5

There are also a large number of agricultural users who have tapped the groundwater; therefore, the groundwater yields cannot be accurately estimated without additional study. The estimated yield values for this study, as summarized above, are based on communications with local water purveyors. However, it is critical that the firm yield of the groundwater be determined accurately if the results of the reservoir staging analyses are to be accurate. It will be shown later that the one million gallons per day of available groundwater is worth 2700 acre-ft of reservoir storage during the design dry cycle.

Imported water

44. Santa Cruz County has the option to purchase 17,800 acre-ft of water per year from the San Felipe water project of the U. S. Bureau of Reclamation. This water can be developed economically as it requires only the construction of treatment facilities and a transmission line from the project to the service areas. Storage of the water may be required if the flows from the San Felipe project are not constant. An important consideration in the construction of the transmission facility is the flow rate at which the water is delivered. If it is constant throughout the year, then very little storage is required and a 30-in. pipeline is adequate. However, if it is delivered during a short time period, a large storage volume will be required with larger and more expensive transmission lines.

45. The imported water is most likely to be used in the Watsonville area; however, some of this water may be used in the Aptos-Soquel area. An additional transmission line would be required which would reduce the need for surface storage in those areas.

Treated water

46. Treated water from low-quality sources can be used. There is virtually no upper limit to the quantity of water that can be supplied by treated wastewater or brackish water. Desalinization of water is a costly, energy-intensive source, whereas recycled wastewater is not as costly but most municipal users will not use these sources regardless of the degree of treatment. The constraints on these sources are based on economic, health, energy, and sociological considerations.

47. Treated water from low-quality sources will not be given serious consideration in the following analysis because there is sufficient water available from other sources. As such, treated water will have no impact on the storage requirements determined later in this part of the report. Nevertheless, the land application of wastewater for agriculture, landscape, or aquifer recharge should be studied in Stage 3 to determine if it is feasible and if it will result in significant conservation of groundwater supplies.

Surface water storage

48. Once surface water direct diversions, groundwater, and imported water have been developed to their fullest, there will still be a need for water to be held in reserve during dry periods. The key question is how much storage must be provided to meet the water requirement for future years. Possible answers to this question are presented in Part IV.

Facilities Required to Transport and Treat Water

49. In addition to the wellfield diversions and reservoirs required to supply adequate water, sufficient pumping, treatment, and transmission capacities must be developed to meet safe drinking water standards. The design parameters for the treatment and transmission facilities are presented in more detail in Part V.

50. Treatment plant costs for facilities using surface water sources are based on solids removal and chlorination costs. Costs for facilities which use groundwater are based on chlorination only.

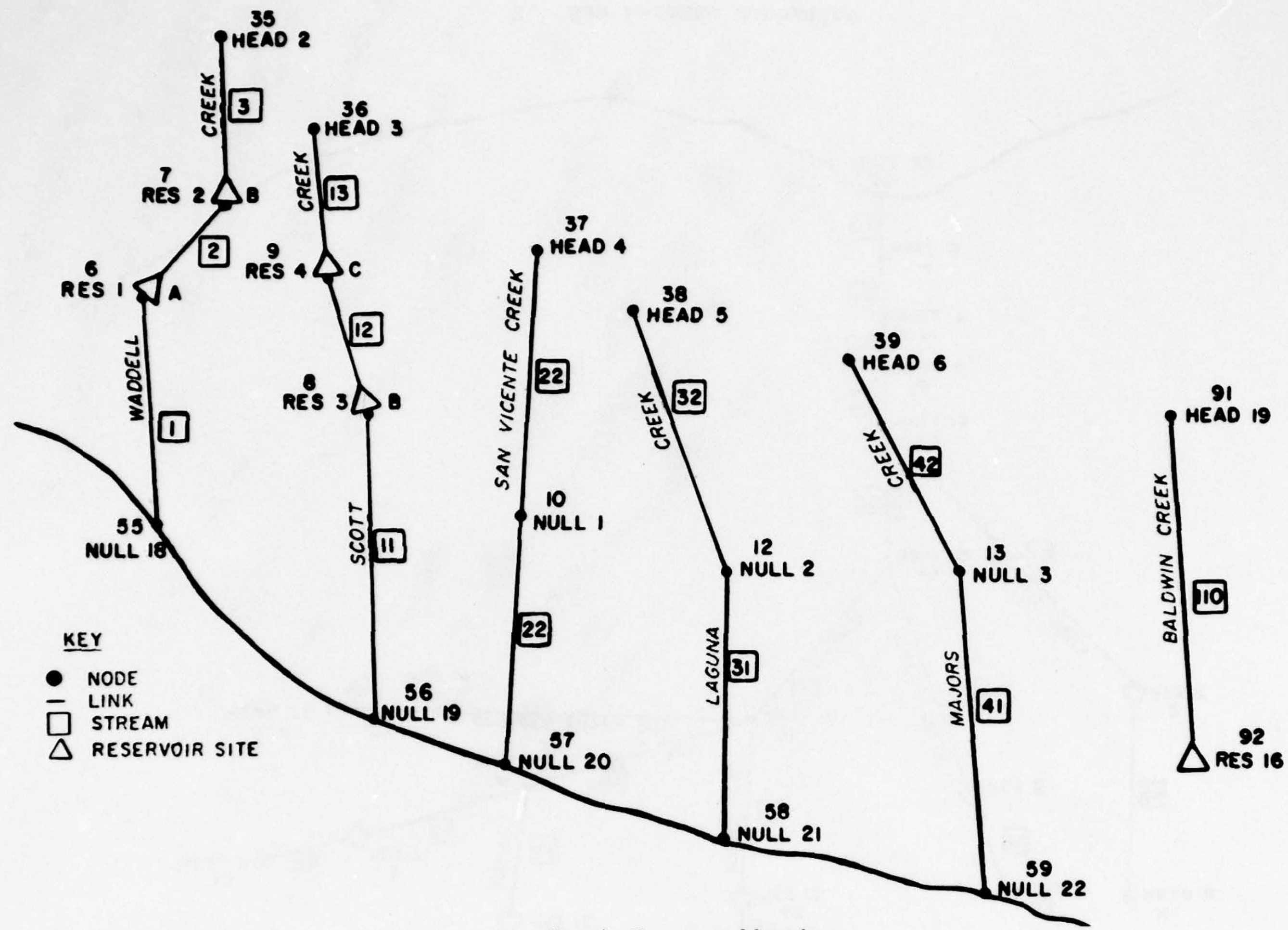
PART IV: MAPS SIMULATION FOR SANTA CRUZ

51. The Santa Cruz portion of the study area was transformed into a hydrologic network, so that MAPS could be used to simulate the water flow and design facilities and estimate their cost. Before facilities could be designed, it was necessary to simulate streamflows in the study area. An example of the hydrologic network of links and nodes is shown in Figure 3. The hydrologic network represents streams, headwaters, and reservoir sites. The numbers in the boxes represent stream reaches and the numbers of the triangles (RES N) describe the nodes. For example, in Figure 3, RES 2 is node No. 7, to which reservoir 2 (Waddell Creek Site A-lower reservoir) has been assigned. The links and nodes used in Figure 3 for the hydrologic network are consistent for all MAPS simulations. The nodes and links in this hydrologic network are given in Tables A1 and A2 of Appendix A.

Subareas

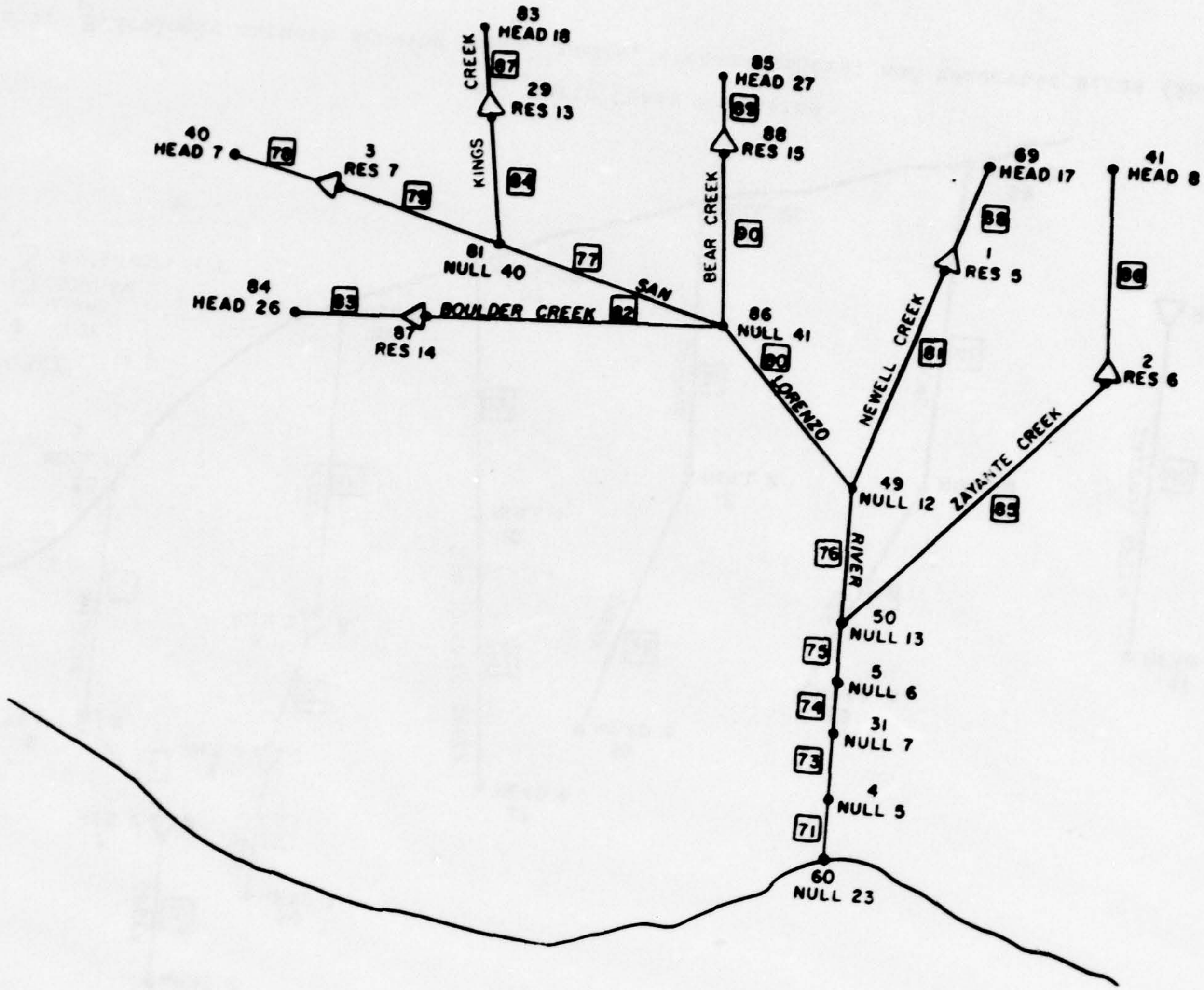
52. The Santa Cruz area was divided into three subareas (Figure 2, Part III, and listed in paragraph 30, Part III). Subarea S is the San Lorenzo Area (inclusive of the North Coast streams) which stretches from the San Mateo County line to the divide between the San Lorenzo River and Soquel Creek drainage basins. Subarea A represents the area between the San Lorenzo River basin and Pajaro River basin; the area is drained by Soquel Creek and Aptos Creek. Subarea P includes Corralitos Creek and the Pajaro River drainage area.

53. The partitioning of the Santa Cruz area into subareas allows problems in a given segment to be analyzed in detail without the necessity of simulating the entire area. For example, in an S plan, the operation of Loch Lomond and a reservoir on Zayante Creek was studied to determine the best operation without considering withdrawal from Corralitos Creek for Watsonville. Then, when the analysis of the S plan had been completed, it was combined more easily with A and P plans.



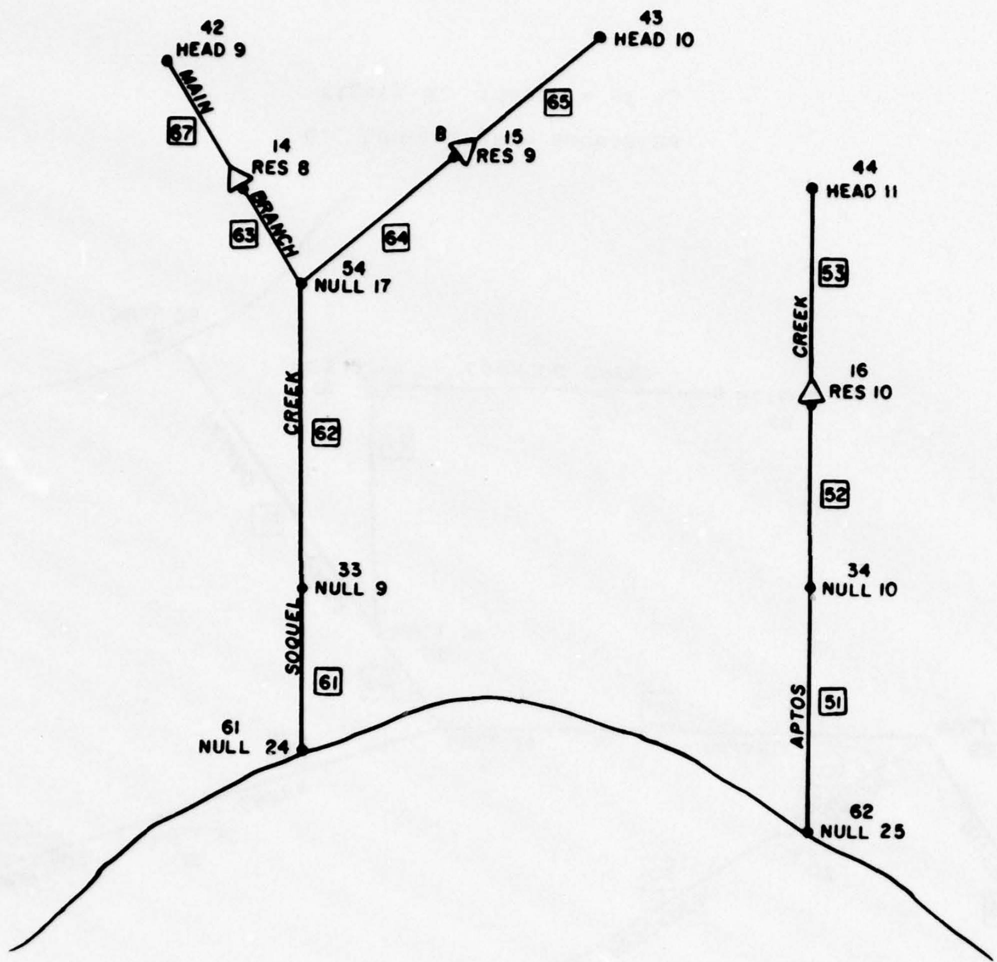
a. North Coast subbasins

Figure 3. Hydrologic network showing links, nodes, stream numbers, and reservoir sites (Sheet 1 of 4)



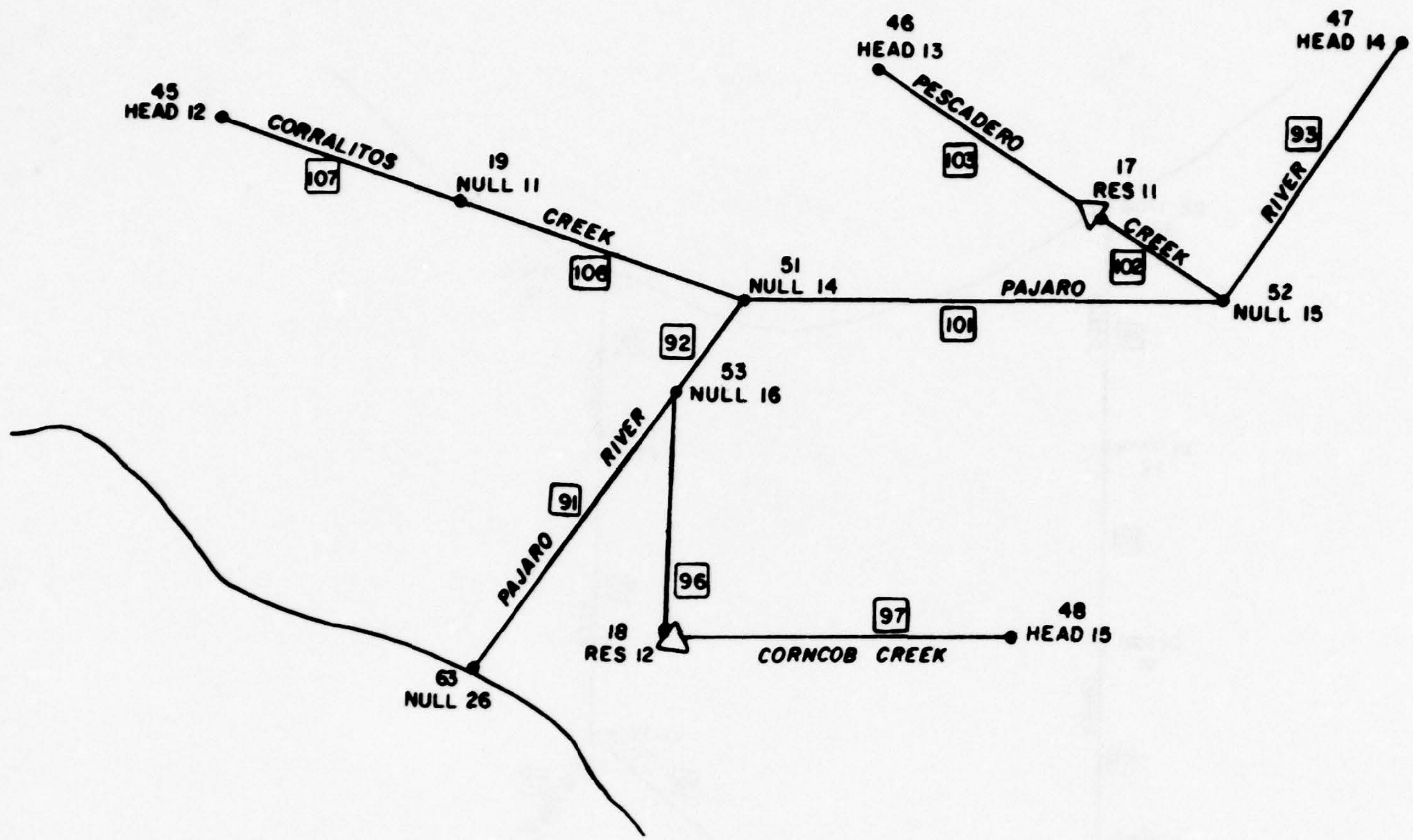
b. San Lorenzo subbasins

Figure 3. (Sheet 2 of 4)



c. Aptos-Soquel subbasins

Figure 3. (Sheet 3 of 4)



d. Lower Pajaro subbasins

Figure 3. (Sheet 4 of 4)

Drainage Areas

54. The more complicated drainage areas, e.g., San Lorenzo (136.1 square miles), Aptos-Soquel (77.0 square miles), and Pajaro Basins (130.0 square miles), were partitioned into the various linkages of headwaters and streams as shown in Tables A4-A6 in Appendix A.

Reservoirs in Santa Cruz Area

55. The reservoir nodes represent either stored water, water flowing through them, or released water. The reservoir is characterized by the average reservoir surface area, the elevations at which the reservoir can be operated, and the release level the user specifies for the simulation, i.e., the reservoir is to be drawn down, filled, or nonexistent.

56. A listing of the reservoirs and their characteristics is given in Table 1. This listing includes the mod number and title, followed by the storage volume, area, evaporation, and dam height information. The average area is the storage volume divided by the difference between the maximum and minimum elevation. The program calculates the elevation of the reservoir at the end of each month during the design dry cycle. The outflow was controlled by the minimum release specified for the reservoir and the water use at the service area(s) using the reservoir in the specified year. The program was also used to calculate the cost of each reservoir.

Service Areas in Santa Cruz

57. The service area modules are used to determine the amount of water to be withdrawn from streams or reservoirs for use. The use at a service area is the sum of the domestic, industrial, and agricultural water use. Since most of the water use by municipalities in the study area is for domestic purposes, domestic use accounted for all of the

Table 1

Reservoir Data*

Reservoir, Mod No.	Storage 1000 acre-ft	Average Area acres	Evaporation acre-ft/yr	Corrected Storage 1000 acre-ft	Height of Dam ft
Loch Lomond**, 5	8.7	91	300	7.9	97
Zayante Creek, 6	25.8	129	426	24.7	200
Scott Creek, 3	32.8	222	733	31.0	148
Glenwood Reservoir, 8	11.8	62	205	11.3	190
Pescadero Creek, 11 (w/pumping)	25.8	125	396	24.0	200
Pescadero Creek, 11 (wo/pumping)	12.2	81	267	11.5	150
Waddell Creek, 1	28.8	120	396	24.2	240
Baldwin Creek, 16	6.5	65	214	6.0	100
Upper Soquel Creek, 9	20.4	75	248	19.8	270
Waterman Switch, 7	7.7	49	162	7.3	160
Kings Creek, 13	8.0	50	165	7.6	160
Bear Creek 15	12.8	128	422	11.7	100
Jamison Dam, 14	10.2	68	495	9.0	150
Aptos Creek, 10	9.0	69	228	8.4	130
Corncob Canyon, 12	14.0	80	264	13.4	200

* Ranked in order of preference.
** Existing reservoir.

water requirements. The industrial use was accounted for by increasing the per capita water use. The agricultural use was not considered since this need is almost exclusively supplied by private wells.

58. The average flow for the service area was used in this study since there exists sufficient storage in the system to dampen out any instantaneous peak flows. It is possible to analyze for such peaks if desired. If conservation practices are adopted, this can be accounted for in MAPS by decreasing the per capita usage.

59. There are six service areas in the Santa Cruz area. The service areas and the nodes to which they are assigned are given in Table A7 of Appendix A. There are three sets of population projections for each service area. The population size and average water usage in million gallons per day used for the various projections is given in Table A3 of Appendix A. Note that the population size given is for the area served by the municipal system. This explains the low flows to the San Lorenzo service area in the 1980 period, i.e., no municipal customers. The flows for that service area increase over time to account for increased service in future years.

Facilities for Source Requirements

60. The characteristics of the reservoirs in the Urban Study area are summarized in Table 1. They are listed in an order of preference based on size, location, probable cost, and relocation problems which corresponds to the order in the staging analysis.

61. The reservoir sizing analysis was simplified because, during the design dry cycle, the flows into the reservoir were nearly zero. During the dry cycle, the inflows and outflows of the reservoirs approached steady-state. For the purpose of the MAPS simulation, the inflow was set equal to outflow plus seepage losses and the stored water was the water supply for the service area. The length of the drought was determined by recording the time during which inflow to the reservoir was nearly zero. The time for simulation was selected as 900 days during which it requires 2700 acre-ft of storage to supply water at

1 mgd. Lake evaporation in the Santa Cruz area is approximately 40 in./yr.

Staging Diagrams

62. As stated earlier, there is a wide variety of staging plans simulated with MAPS that could meet the water supply needs of the Santa Cruz area. In order to provide decision makers with a tool for comparing alternatives, a set of staging diagrams was prepared showing the storage required for each year of the plan horizon (Figure 4). Each path through the staging diagram represents a plan. The water sources are represented by line segments in each plan. The beginning of the line segment represents the year by which the source must be developed in order to meet the demands caused by the design droughts in that year. The end of the line segment corresponds to the year by which the next source must be developed. Note that the year the facility is required depends on which population projection proves to be correct. The three population projections correspond to three horizontal time lines in the staging diagrams. However, plans have two diagrams prepared depending on the upper limit of the groundwater yield.

63. Groundwater, surface water direct diversions, and imported water are generally less expensive sources and can be developed faster than reservoirs. They are therefore staged first and reservoirs are staged in the order given in Table 1. The staging order of reservoirs is based on the size, location, probable cost, and relocation problems. To distinguish between the various alternatives for each subarea, a number is assigned to each plan. The numbers 1-50 are used for surface water intensive plans, and 51-100 for groundwater intensive plans. For example, in the San Lorenzo subarea, plan S.10 is a surface water intensive plan while plan S-52 assumes a greater degree of groundwater development.

64. Each reservoir is represented on the diagram by a line segment. The beginning of the line segment indicates the year the reservoir is to be completed if the design drought occurs in that year. The

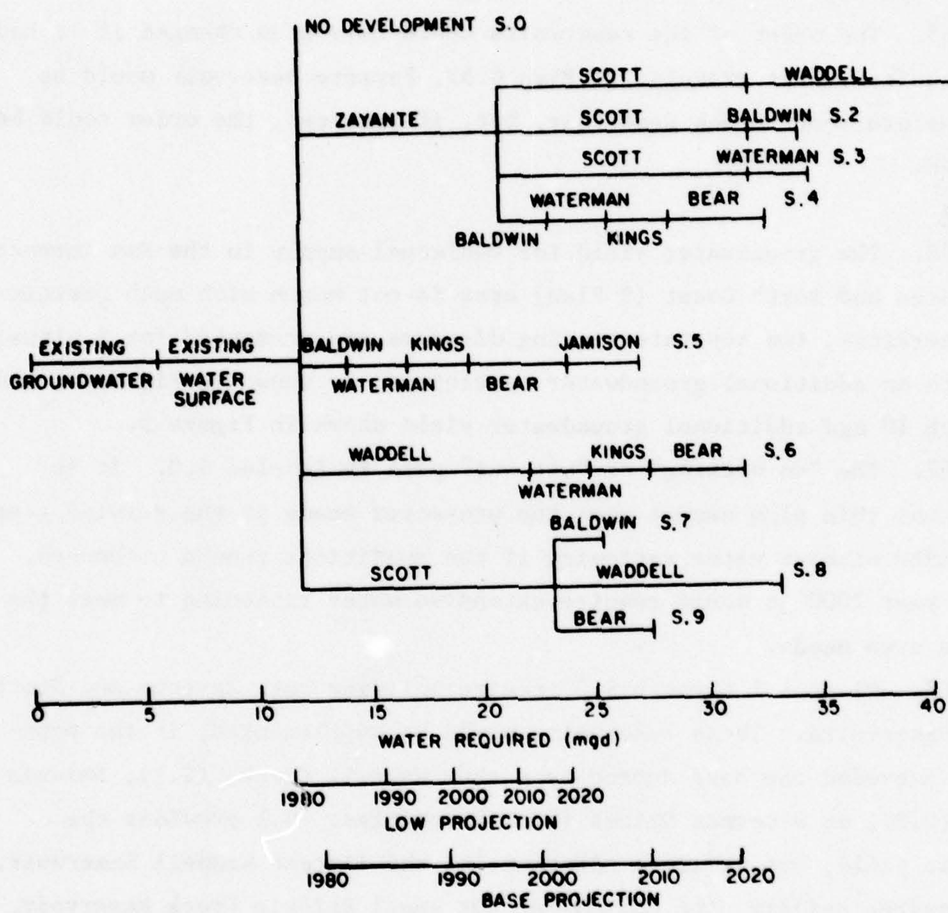


Figure 4. Staging diagram for Plans S.0-S.9

end of the line segment indicates the year the reservoir will fail to meet the needs of the service area if the drought occurs in that year. For example, under plan S.5, Kings Creek Reservoir must be built in 1995 if the low population projection proves to be true, and will run out of capacity to meet the design drought in 2003.

65. The order of the reservoirs could have been changed if it had been required. For example, in Plan S.53, Zayante Reservoir would be built before Scott Creek Reservoir, but, if required, the order could be switched.

S Plans

66. The groundwater yield for municipal supply in the San Lorenzo River area and North Coast (S Plan) area is not known with much certainty. Therefore, two separate staging diagrams are presented for S plans; (1) with no additional groundwater development as shown in Figure 4, and (2) with 10 mgd additional groundwater yield shown in Figure 5.

67. The "do nothing" or "without" plan is labeled S.0. It is clear that this plan cannot meet the projected needs of the service area after 1980 without water rationing if the conditions remain unchanged. By the year 2000 it would require extensive water rationing to meet the service area needs.

68. Plans S.1 through S.3 require building both Zayante and Scott Creek Reservoirs. These reservoirs would be supplemented, if the population exceeded the base demand by either Waddell Creek, (S.1), Baldwin Creek (S.2), or Waterman Switch (S.3) Reservoirs. S.1 provides the greatest yield, but requires constructing the distant Waddell Reservoir. S.2 requires building the convenient but small Baldwin Creek Reservoir, while S.3 requires building a reservoir (either Waterman, Kings, or Bear Reservoir) on the upper San Lorenzo River which would be convenient for water users in the area as it would not require pumping from downstream.

69. Plan S.4 shows the development that must be done if Zayante Creek is the only large reservoir that can be built. Plan S.5 covers the case where only Baldwin Creek and the upper San Lorenzo River Reservoirs (Waterman, Kings, or Bear Reservoirs) could be built.

70. Plan S.6 gives the best alternative if both Zayante and Scott

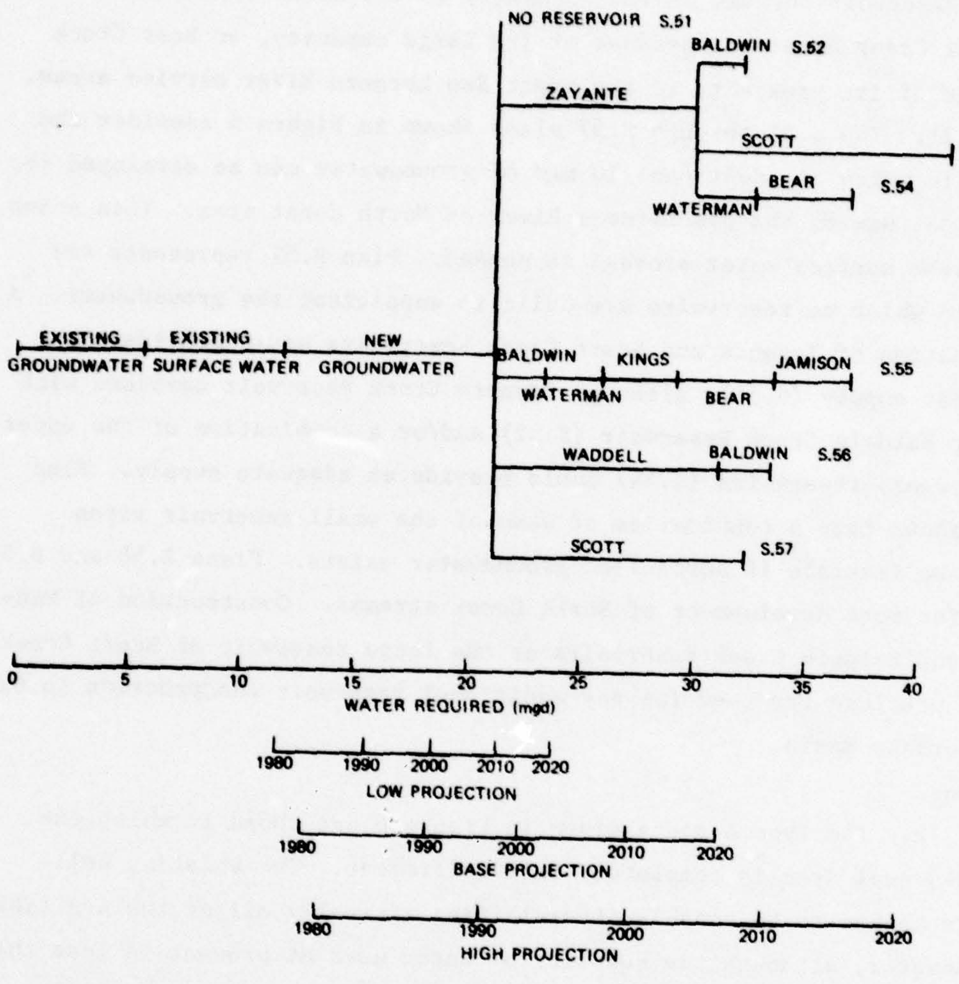


Figure 5. Staging diagram for plans S.51-S.57

Creek Reservoirs could not be built. Plans S.7 through S.9 give the best plans if Scott Creek Reservoir can be built but not Zayante Creek Reservoir. The Scott Creek Reservoir water supply can be supplemented by constructing one of the following alternatives such as the Baldwin Creek Reservoir because of its proximity to the Santa Cruz service area, Waddell Creek Reservoir because of its large capacity, or Bear Creek because of its proximity to the upper San Lorenzo River service areas.

71. The S.51 through S.57 plans shown in Figure 5 consider the cases in which an additional 10 mgd of groundwater can be developed for municipal use in the San Lorenzo River or North Coast area. This means that less surface water storage is needed. Plan S.51 represents the case in which no reservoirs are built to supplement the groundwater. A combination of Zayante and Scott Creek Reservoirs would provide the greatest supply (S.53), although Zayante Creek Reservoir combined with either Baldwin Creek Reservoir (S.52) and/or a combination of the upper San Lorenzo reservoirs (S.54) could provide an adequate supply. Plan S.55 shows that a combination of some of the small reservoir sites could be feasible if sufficient groundwater exists. Plans S.56 and S.57 call for more development of North Coast streams. Construction of Waddell and Baldwin Creek Reservoirs or the large reservoir at Scott Creek would preclude the need for any additional reservoir construction in the San Lorenzo Basin.

A Plans

72. The Type A plans given in Figure 6 are those in which the Aptos-Soquel area is completely self-sufficient. The existing wellfields appear to be capable of exploiting virtually all of the available groundwater, although the quantity of water used at present is less than the wellfield yield. Plan A.0 is the "without" plan. If it is implemented, existing groundwater yields will provide sufficient flow for several years.

73. Plan A.1 and A.2 consider the case in which Glenwood Reservoir is built first and then supplemented later by either the Upper Soquel or Aptos Creek Reservoir. Glenwood Reservoir is adequate by itself only if the population growth rate remains low.

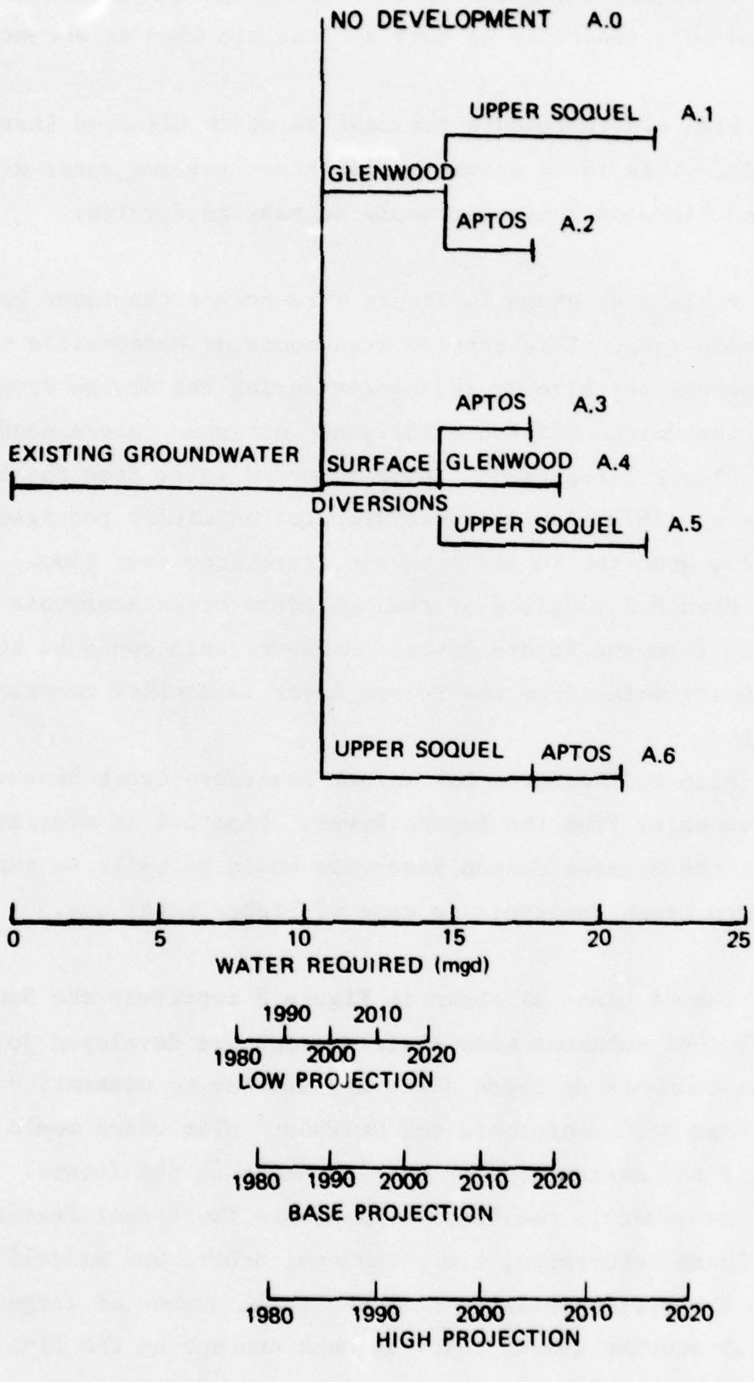


Figure 6. Staging diagram for A plans

74. Plans A.3 through A.5 would utilize surface water direct diversions on Soquel and Aptos Creeks. These stream diversions are supplemented by a reservoir as much as possible when it becomes necessary.

75. Plan A.6 represents the case in which Glenwood Reservoir cannot be built. This is an unlikely plan since surface water direct diversions and Glenwood Reservoir would be easy to develop.

P Plans

76. P plans as shown in Figure 7 represent the lower Pajaro Valley service area. This service area contains Watsonville whose existing sources are already inadequate during the design drought; therefore, the "without" plan (P.0) would not meet future needs.

77. Plan P.1 represents using imported water from the San Felipe water project. This plan includes storage facilities required to regulate the flow when the supply or usage fluctuates over time.

78. Plan P.2 consists of the Pescadero Creek Reservoir without back-pumping from the Pajaro River. However, this could be supplemented by back-pumping water from the Pajaro River to another reservoir at Corncob Canyon.

79. Plan P.3 features the larger Pescadero Creek Reservoir which will receive water from the Pajaro River. Plan P.4 is similar to P.3 except that the Corncob Canyon Reservoir would be built to supplement the Pescadero Creek Reservoir in case of higher water use.

SA Plans

80. The SA plans as shown in Figure 8 represent the San Lorenzo and Aptos-Soquel subareas when their sources are developed jointly. Many of the comments on these plans are similar to comments on the S and A plans. Plan SA.0 represents the "without" plan which would not meet the needs if the design drought were to occur in the future.

81. In general, the best SA plans are those that feature a small number of large reservoirs, i.e., Zayante, Scott, and Waddell. It is clear from the staging diagram that the small number of large reservoirs in Plan SA.1 provide almost twice as much storage as the five small reservoirs used in Plan SA.10.

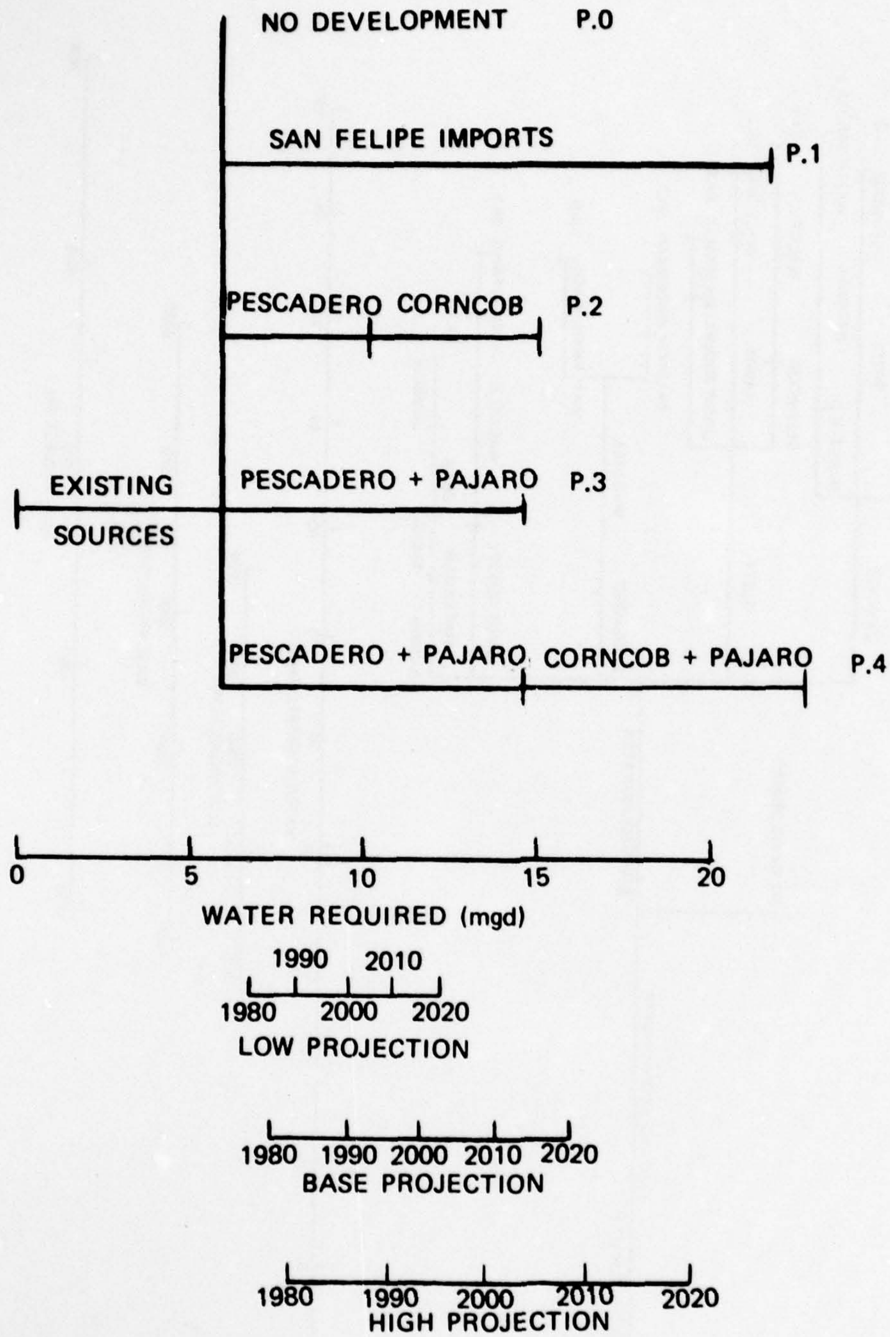


Figure 7. Staging diagram for P plans

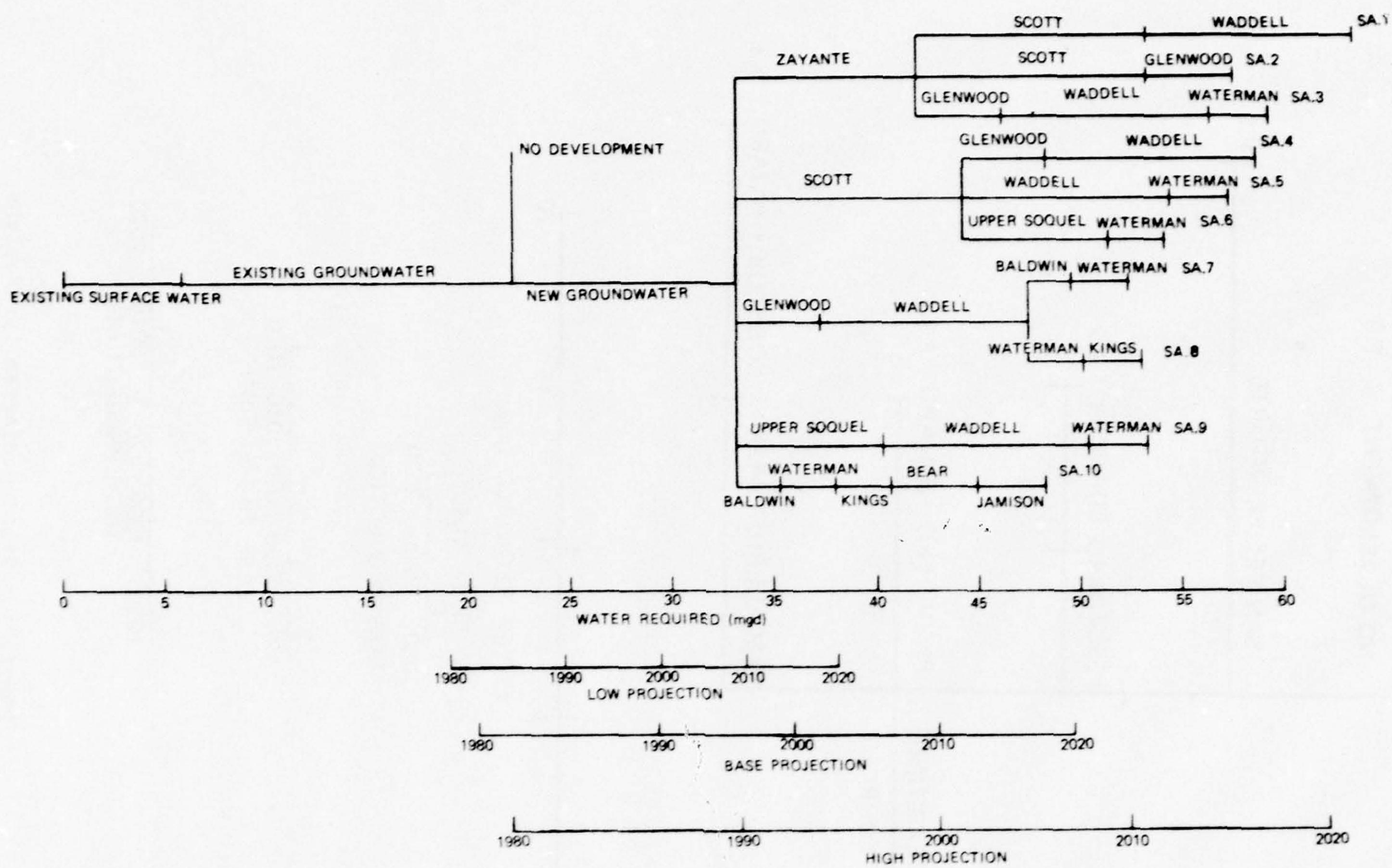


Figure 8. Staging diagram for SA plans

82. The Waterman Switch Reservoir was included in many of the plans, not because of its capacity, but rather because of its proximity to the upper San Lorenzo service areas. While the Waterman Switch Reservoir is mentioned in each of the plans, the same result could be achieved by using one of the upper San Lorenzo Reservoir sites.

83. In general, the SA plans require water to be transported from the North Coast area to the Aptos-Soquel area by way of the City of Santa Cruz. The question of whether Santa Cruz would permit water to be transported through it must be resolved before the plans could be implemented.

SAP Plans

84. The SAP plans as shown in Figure 9 differ from earlier plans in that the Watsonville service area is connected with the Aptos-Soquel and San Lorenzo service areas. These are actually two different plans depending on the direction in which the water is to be transported. They depend upon exercising the option to purchase imported water from the San Felipe Project. If Plans SAP.2 and 3 are implemented, the flow will be from Watsonville northward. If Plans SAP.2 and 3 are not chosen, then the San Lorenzo and North Coast areas would transport water south to Watsonville as shown in Plan SAP.1. There are many plans similar to SAP.1, but it was chosen because it includes the best reservoir sites.

Minimum releases

85. The minimum release required from reservoirs is a very important variable in determining the feasibility of using a reservoir for water supply. The staging analyses were based on the assumption that during dry periods releases would be approximately equal to the inflow and that during wet periods releases would be approximately 60 percent of inflow or 5 cfs (whichever is smaller) until the reservoir spilled.

86. The U. S. Fish and Wildlife Service may require that 60 percent of the runoff be released for fishery enhancement. If this is interpreted to mean that the minimum release must be 60 percent of the inflow during dry periods, the results presented in the staging diagrams would not be affected since the inflows were virtually zero throughout

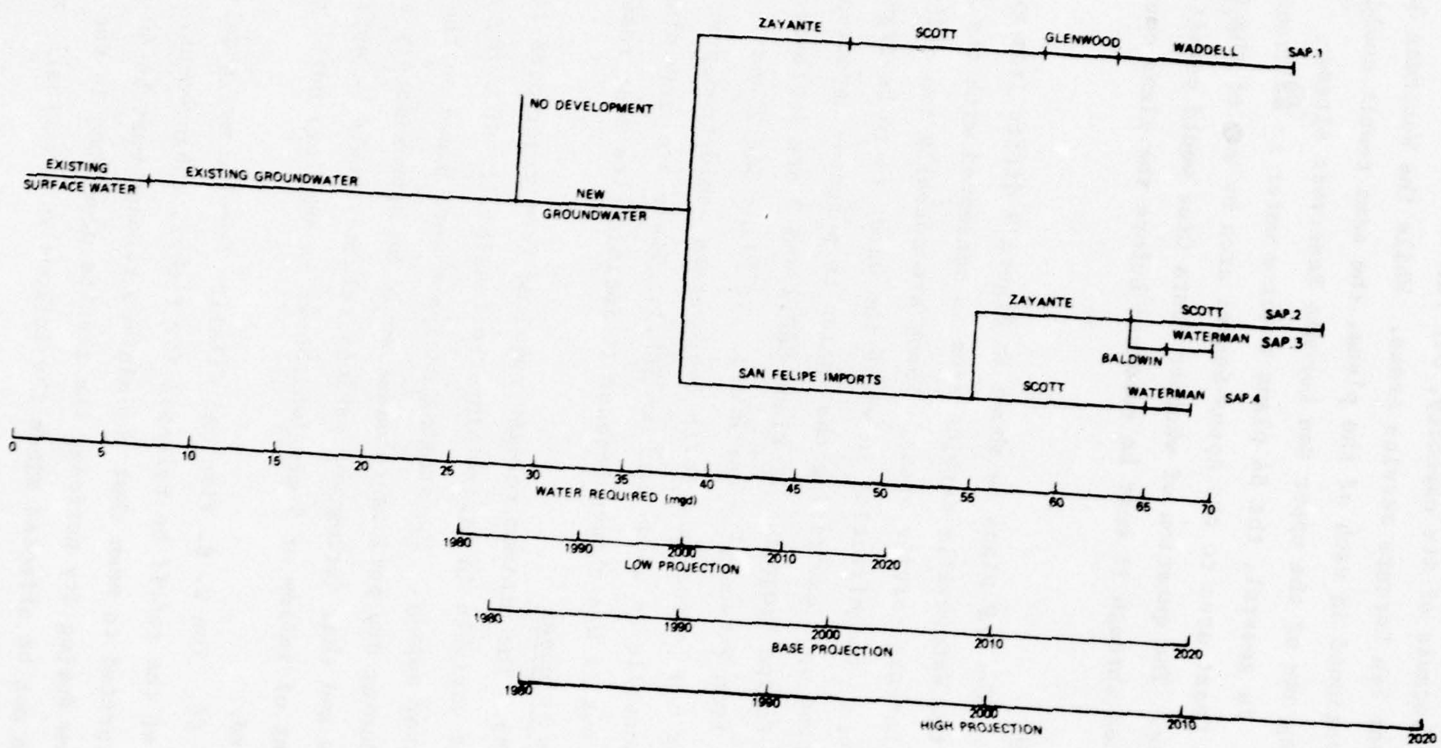


Figure 9. Staging diagram for SAP plans

the drought. The yields of the reservoirs would be reduced because it would take longer for them to fill after the drought.

87. If 60 percent of the average annual flow must be released throughout the year for the U. S. Fish and Wildlife Service, then the reservoirs proposed by this analysis cannot be used because the runoff into them and their storage would have to be used to maintain streamflows. During the dry period the flows in almost every stream were well below 60 percent of their average annual value. For example, the average flow at the damsite on Pescadero Creek is 2254 acre-ft/yr. The total flow past that site during the 900-day drought was 1978 acre-ft; nevertheless, 3381 acre-ft, or 60 percent of 5635 acre-ft, would be required to be discharged. Not only is the 1978 acre-ft lost to Watsonville, but 1403 acre-ft of stored water must be released and not used in Watsonville. The impact of the U. S. Fish and Wildlife Service release plan is even more dramatic on some other streams. Therefore, the release plans should be defined exactly during Stage 3 of this study. If not, a sensitivity analysis of the effects of the 60 percent release requirement should be done.

Water conservation

88. The enforcement of water conservation policies, adoption of operational practices, and installation of equipment will also reduce future water uses. If these changes occur, the quantity of water demanded in each year must be calculated. Another time line can then be plotted on the existing staging diagrams to represent the water required in each year with conservation.

89. Figure 10 shows what the staging diagram for S plans would look like if the base population projection were used and a 75 percent across-the-board water conservation policy were implemented. There is no need for the cutback unless a drought is occurring; therefore, an indicator, e.g., flow in the San Lorenzo River below 20 cfs, should be used to implement this policy. Note that application of water conservation to the base growth projection reduced water requirements to a level slightly below the low projection.

90. The construction of these reservoirs could also impact on the

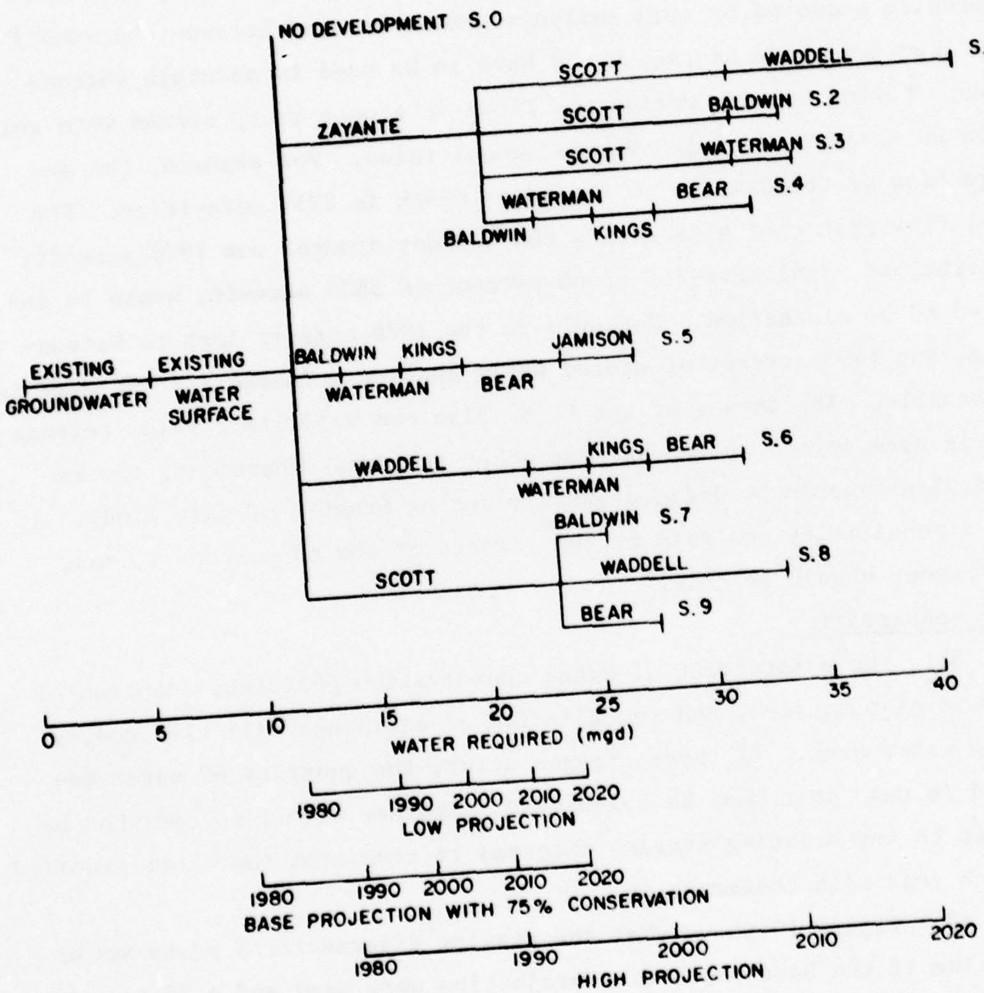


Figure 10. Staging diagram for S plans with conservation

population growth in the area. Construction of Waddell or Scott Creek Reservoirs could spur development in the North Coast area while construction on the upper San Lorenzo River Reservoir could accelerate developments in that area. These features should be studied in more detail in the Stage 3 Planning Phase.

PART V: FACILITY PLANS FOR SANTA CRUZ

91. Facility planning for this study consists of providing sufficient capacity for transmission and treatment of water. The transmission, piping, and pumping capacity is developed to transmit water from the sources to the service areas. The treatment capacity is developed to meet safe drinking water standards. The following sections present the required transmission facilities and treatment plants used in the study area.

Transmission Facilities

92. Nine new or improved transmission projects may be built depending on which alternative is used. A transmission project is a set of facilities which must be built concurrently. If one of the North Coast reservoirs, Scott Creek or Waddell Creek, is built, a new North Coast pipeline must be built to handle 10 mgd capacity if one reservoir is built, or 20 mgd if both are built. At the time this pipeline is installed, a pipeline diversion at San Vicente Creek should be built. This new pipeline would not extend to the Graham Hill Treatment Plant, but rather to the new Gordola Treatment Plant.

93. The upper San Lorenzo Reservoirs will require a pipeline to transport 4 mgd of water from the reservoir to the upper San Lorenzo treatment plant. If more than one of the upper San Lorenzo reservoirs are built, reservoirs would supply more water than the area would demand. The remaining water would be transported to the City of Santa Cruz. However, it would be unwise for the City of Santa Cruz to treat the water at the upper San Lorenzo Plant since it would not use the capacity of the plant during the wet seasons. Therefore, Santa Cruz has two options: the first is to pipe the water to Graham Hill treatment plant by way of Felton Pumping Station; the second is to release the water into the San Lorenzo River and then divert it at Graham Hill. The second option is considerably less expensive and should be utilized if it can be shown that the flow will not be lost between the reservoir and the

Graham Hill Treatment Plant intakes.

94. There are two purposes for the raw water transmission lines in the Zayante Creek Valley: to carry water during wet periods from the San Lorenzo River via the Felton Pumping Station to the Zayante Creek Reservoir and to carry water from the reservoir to the treatment facilities during dry periods. The Felton Pumping Station must be upgraded from 10 to 20 mgd to handle the additional flows to and from Zayante Creek Reservoir. The untreated waterline from the Felton Pumping Station to Graham Hill Treatment Plant has sufficient capacity to handle the additional flow from the Zayante Creek Reservoir.

95. A treated water main must be installed to serve the Lompico, Olympia, and Zayante communities when the wellfields in this area become inadequate. The most likely plant to provide the water is the Felton Treatment Plant. However, if it is not built, a small treatment facility drawing raw water from Zayante Creek may be required to serve this area.

96. An Aptos-Soquel coastal pipeline for treated water will be required in A plans to serve the LaSelva area, in type SA plans to connect the Aptos-Soquel service with the City of Santa Cruz, and in type SAP plans to connect with the Watsonville system along Freedom Road. Even if major transfers of water between service areas are not envisioned, construction of the coastal pipeline would allow the service areas to transport water between them in time of emergencies.

97. Untreated water transmission lines would be required to connect the Aptos-Soquel Treatment Plant with the Glenwood and/or Upper Soquel Reservoirs and with the diversions or reservoirs on Aptos Creek. The transmission lines from the Soquel Creek Reservoirs and the diversions can be gravity lines, but a pump station is required to transport Aptos Creek water across the divide to the treatment plant. If it is not cost-effective to pump Aptos Creek water across the divide, then a small treatment plant could be located on that stream below Nicene State Park.

98. The most important transmission line in the lower Pajaro subbasin is the line between the San Felipe Project and the Watsonville

service area. This transmission line would follow the Pajaro River to Watsonville. If the water imported from the San Felipe project is used for irrigation, then transmission lines from the existing wellfields could be connected to the City of Watsonville. The storage of imported water will be in the Pescadero Creek or Corncob Canyon Reservoir in which case pumping stations will be required to lift the flow from the river valley into the reservoirs.

99. If the Pescadero Creek Reservoir is utilized, an untreated waterline will be required to connect it with the Watsonville water treatment plant. A pumping station and pipeline from the Pajaro River to the reservoir would be required if the scheme with backpumping is selected. The transmission line from the Pescadero Creek Reservoir will be 10 mgd with backpumping, and 5-mgd without backpumping.

100. If the Corncob Canyon Reservoir is constructed, a pumping station will be required to lift water from the Pajaro River to the reservoir. The same 5-mgd pipeline could be used to transport water from the reservoir to the water treatment plant.

Treatment Facilities

101. In general, treatment facilities should be in or near the respective service area rather than at the water source. The facilities discussed below will be used exclusively for the treatment of surface water because groundwater supplies will require only chlorination to meet water quality standards.

102. Treatment facilities will not be required for each of the alternative plans; however, most plans will require a combination of several treatment facilities. The proposed treatment facility plants and upgrading of existing plants are designed to treat the total flow from the water source even though plant construction could be staged. The individual treatment facilities are described below.

103. The Graham Hill Treatment Plant serves the city of Santa Cruz and vicinity. It is presently receiving water from the San Lorenzo River, the North Coast diversions, and Loch Lomond, and it will be

used to treat the flow from the Zayante Creek Reservoir for use in the Santa Cruz and Scott Valley area. Alternative plans for reservoir construction in the upper San Lorenzo area assume that the additional yield would be treated at Graham Hill.

104. The existing Watsonville Treatment Plant at Corallitos Creek must be upgraded to treat the additional surface water supply from the San Felipe Project, Pescadero Creek, and the Pajaro River. The need for treatment may be reduced somewhat if the imported San Felipe water is used for irrigation and the wellfields converted to use for domestic and industrial water supply. If the Corncob Canyon Project is adopted for Watsonville, another treatment alternative would be to construct a new treatment facility at Watsonville Pumping Station to treat Pajaro River water in the wet season and Corncob Canyon Reservoir water in the dry season.

105. A central treatment plant for the Aptos-Soquel service area will be required as the area begins to utilize additional surface water. The best location will be on Soquel Creek just above the urbanized areas.

106. Depending on the source from which the upper San Lorenzo Valley service area will draw water, one of the two alternative treatment plants will be required. If one of the proposed upper San Lorenzo River reservoirs, e.g., Waterman Switch, Kings Creek, Bear Creek, Boulder Creek, is built, then the most convenient location for a treatment plant which would result in minimum energy usage will be immediately downstream from the reservoir and upstream from the service area. If one of the proposed upper San Lorenzo reservoirs is not built, then during dry periods water must be supplied from either Loch Lomond or Zayante Creek Reservoir to supplement groundwater and surface water direct diversions. The optimal location for the treatment facility would be in Felton since transmission lines from both reservoirs meet there. The Scott Valley service area may elect to purchase water from the Felton Treatment Plant instead of the Graham Hill Treatment Plant if this proves to be more economical. Similarly, if the Graham Hill Treatment Plant cannot be upgraded, a larger treatment plant can be built at Felton to serve the City of Santa Cruz.

107. If a plan is implemented that calls for increased urbanization in the North Coast area, then a treatment plant at Gordola should be constructed. The Gordola Treatment Plant would receive water from the North Coast diversions during the wet seasons and from the Baldwin Creek, Scott Creek, or Waddell Creek Reservoirs in dry seasons and would serve the City of Santa Cruz and North Coast developments. However, this plan is only feasible if at least one of the North Coast reservoirs is built. Otherwise, there would be no inflow to the Gordola Treatment Plant during the dry season and treatment of all the flow at Graham Hill would be economically more practical.

Intermediate Plans for Santa Cruz

108. Intermediate water supply plans for Santa Cruz County are given in Appendix D as a summary of the Stage 2 alternatives. The components of each plan to be built or upgraded are presented in table form and include the year completed, the final capacity, and the average annual cost in 1978 dollars of the facility. Distribution systems are described for the San Lorenzo Valley, Scott Valley, and the Zayante Valley. Only the major pipelines are presented. The value for the "year completed" for each facility was determined using the "base" population projection. These values must be corrected if a higher or lower population growth occurs. Also, changes in per capita use of water could affect the time schedule. The regional plans, such as the SAP plans, generally had lower costs because of economy of scale and more efficient staging.

109. The figures in Appendix D show the networks for the S, A, and P plans. The networks for the SA and SAP plans can be developed by combining the figures for the appropriate S, A, and P plans. No tables are provided for plans S.0, S.51, A.0, P.0, SA.0, and SAP.0 since they represent "do nothing" plans with no reservoir or major pipeline construction.

<u>Design and Economic Criteria</u>

110. A large number of design and cost parameters were required to prepare cost estimates for the various facilities. The sources of these values used in the cost estimates computer program are documented in this portion of the report.

<u>Design factors</u>

111. Elevation versus storage curves for the reservoirs, elevations of facilities, and the drilling depth and drawdowns for wells were taken from the 1968 Master Plan,[5] USGS topographical maps,[6] and from the 1968 report by Hickey.[7] To be rendered potable, surface water supplies would require coagulation, sedimentation, filtration, and chlorination, whereas groundwater supplies would require only chlorination.

112. In designing transmission lines, it was assumed that pipe roughness heights are 0.001 ft and pipes are laid at the 5-ft depth. The lengths of the pipelines and cultural multipliers, which refer to the terrain crossed by the lines, were determined by San Francisco District personnel. The term cultural multipliers refers to the type of terrain through which the pipes are to be laid. A 50-ft easement was required for the transmission lines. The reservoir costs were based on the costs of earth dams.

113. The pumping stations were assumed to be 60 percent efficient with power consumption based on average flow. However, the equipment required at a pumping station was based on the peak flow. The design of the pump stations for backpumping to reservoirs, e.g., Zayante Creek, Pescadero Creek, and Corncob Canyon Reservoirs, is based on the available flow in the river and the available storage at the end of a dry period. The pump stations are sized to provide 20 mgd to the reservoirs. The operation and maintenance costs are based on pumping for a 3-month period each year.

114. In the case of force mains which handle flow in both directions, e.g., between Zayante Creek Reservoir and Felton Pumping Station,

there are two sets of design and cost data that provide an analysis of the flow in each direction. However, there is only one cost figure for each of these pipelines.

115. In many of the facilities, the cost data available were not adequate to separate the operation and maintenance costs into labor, power, and supply, e.g., water treatment plants and reservoirs. In these cases, a single cost function was utilized and the costs were lumped under a "supply" category while labor and power costs were set to zero (Appendices F and G).

Economic factors

116. Cost functions in the MAPS program are based on a synthesis of available parametric cost functions. The remainder of this section discusses input data to the cost functions. The economic data used in this study are presented below. The interest rate used is 6.625 percent as specified by the Water Resources Council. The local multiplier is 1.14, indicating that costs in the study area are 1.14 times greater than the national average. The cost effects of relative inflation on components of a facility are ignored in the analysis. The costs correspond to an Engineering News Record (ENR)[8] Construction Cost Index of 2680, and EPA[9] Sewer Construction Cost Index of 305. The study period ends in the year 2020. Wages for operation and maintenance are based on a salary of $7.50 per hour including overhead. Construction costs contain a 10 percent add on for overhead. Power costs are based on 5¢/kwhr.

Economic Data

EPA Sewer Construction Cost Index	305
EPA Sewage Treatment Plant Cost Index	275
ENR Construction Cost Index	2680
Economic Base Year	1978
Operation and Maintenance Wages	$7.50 per hour
Construction Wages	$7.00 per hour
Electricity Costs	$0.05 per hour
City Multiplier	1.14
Interest Rate	6.63 percent

117. The design life of pumping stations, water treatment plants, and mechanical equipment at wellfields is assumed to be 20 years. The design life of transmission lines and reservoirs is 50 years. Land

and wells (excluding mechanical equipment) have an infinite life. If the design life of a facility is exhausted before the end of the study period, it is replaced by an identical facility. Salvage value of facilities at the end of the study period are based on straight line depreciation. The cost of easements for transmission lines is $1,000 per acre.

118. Land costs for reservoirs were omitted as these costs were small in comparison with the construction cost and it was uncertain as to the amount of land to be purchased for a given reservoir. This will need to be studied in detail since the purchase of large tracts of land to protect the watershed would result in a significant increase in cost.

Examples of Facility Staging

119. Appendix E was prepared to assist in determining the average annual cost of facilities built in any year of the study period. Using these tables it is possible to modify the cost summaries produced in Appendix C if different staging than that used in developing Appendix D is used. The relationship between average annual cost and year built is shown in Figure 11.

120. The average annual cost tables for each facility are presented in Appendix E to compare the costs of different facilities built in different years. The tables contain cost figures in 1978 dollars that must be paid each year if the facility is built in the year indicated at the top of the column. The average annual costs decrease with time because of delayed construction of the facility. Delaying construction also decreases the time at which benefits from the project accrue. To compare the costs on a present worth rather than an annual average cost basis, the average annual cost must be multiplied by the Uniform Series Present Worth Factor. For an interest rate of 6.625 percent over a 42-year (2020-1978) period, the factor is 14.75.

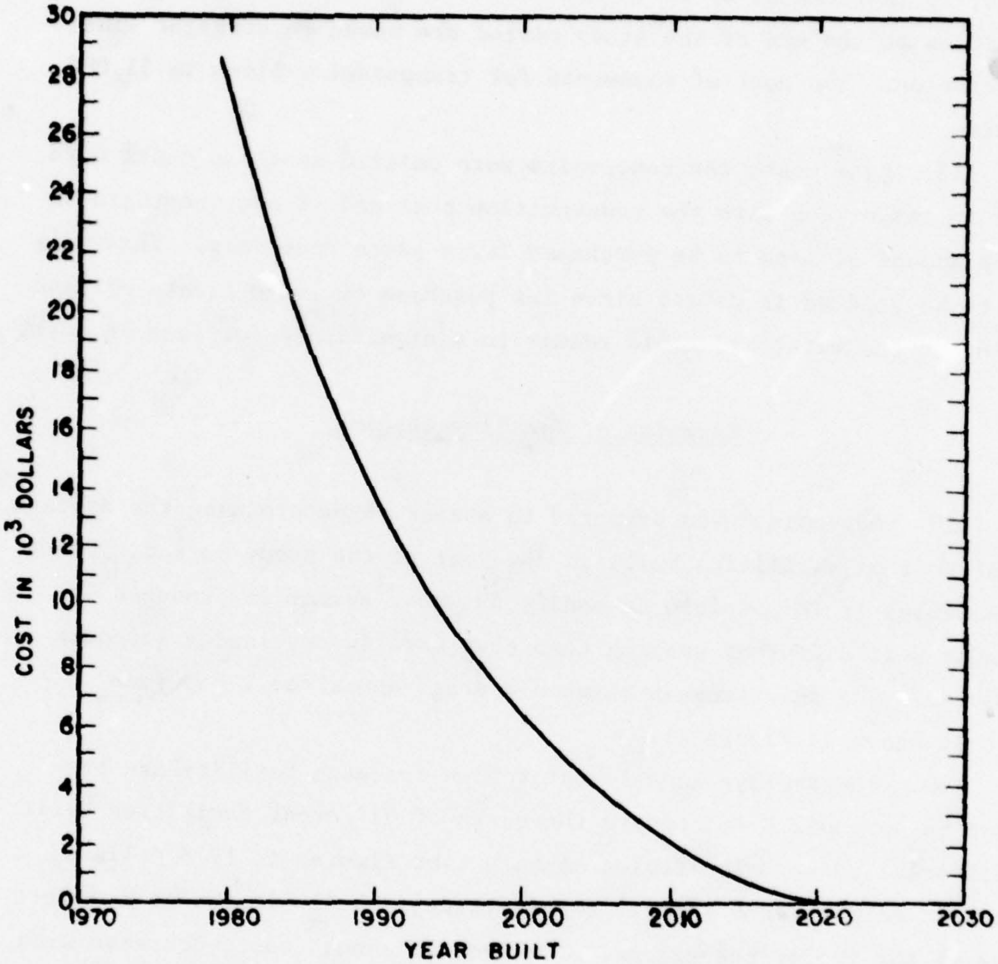


Figure 11. Shape of typical average annual cost versus year built curve

Facility Design Output

121. Design data for each facility are included in Appendix F. The printouts include the design parameters for the facility, the economic parameters used, and a cost summary. The output is presented in exponential notation; that is,

$$0.420E + 02 = 0.420 \times 10^2 = 42.0$$

122. The transmission lines are designed to carry flow with a velocity of approximately 4 fps at average flow. While only one set of head loss calculations per force main are presented in the results, the head losses were determined at several pipe sizes and flows so that an efficient pipe size would be selected.

123. Following the design and cost data sheet is a summary of the costs of the facility depending on the year in which it is built. The costs are divided into four categories: (1) present worth of facilities and replacements; (2) cost of land; (3) total operation and maintenance costs; and (4) salvage value at the end of study period. The present worth of all of these expenditures is given for each time period. The final line contains the average annual cost of the facility, i.e., the amount in dollars that must be paid every year from 1978 to 2020 to construct a facility in any designated year and operate it through 2020. The relationship of these costs for a typical facility is given in Figure 12.

124. The pipelines presented in this report do not correspond exactly with the "links" used in the MAPS simulation runs and listed in the Progress Reports. In some cases a number of links were combined into a single facility. For example, in the MAPS simulation, what is referred to as the "North Coast Pipeline" was separated into a number of shorter links, i.e., Scott Creek to San Vicente Creek, San Vicente Creek to Liddell Creek, etc. This was necessary for the simulations, but for the purpose of this report, it is more convenient to refer to these links as the North Coast Pipeline.

125. Several designs may be possible for each facility, even

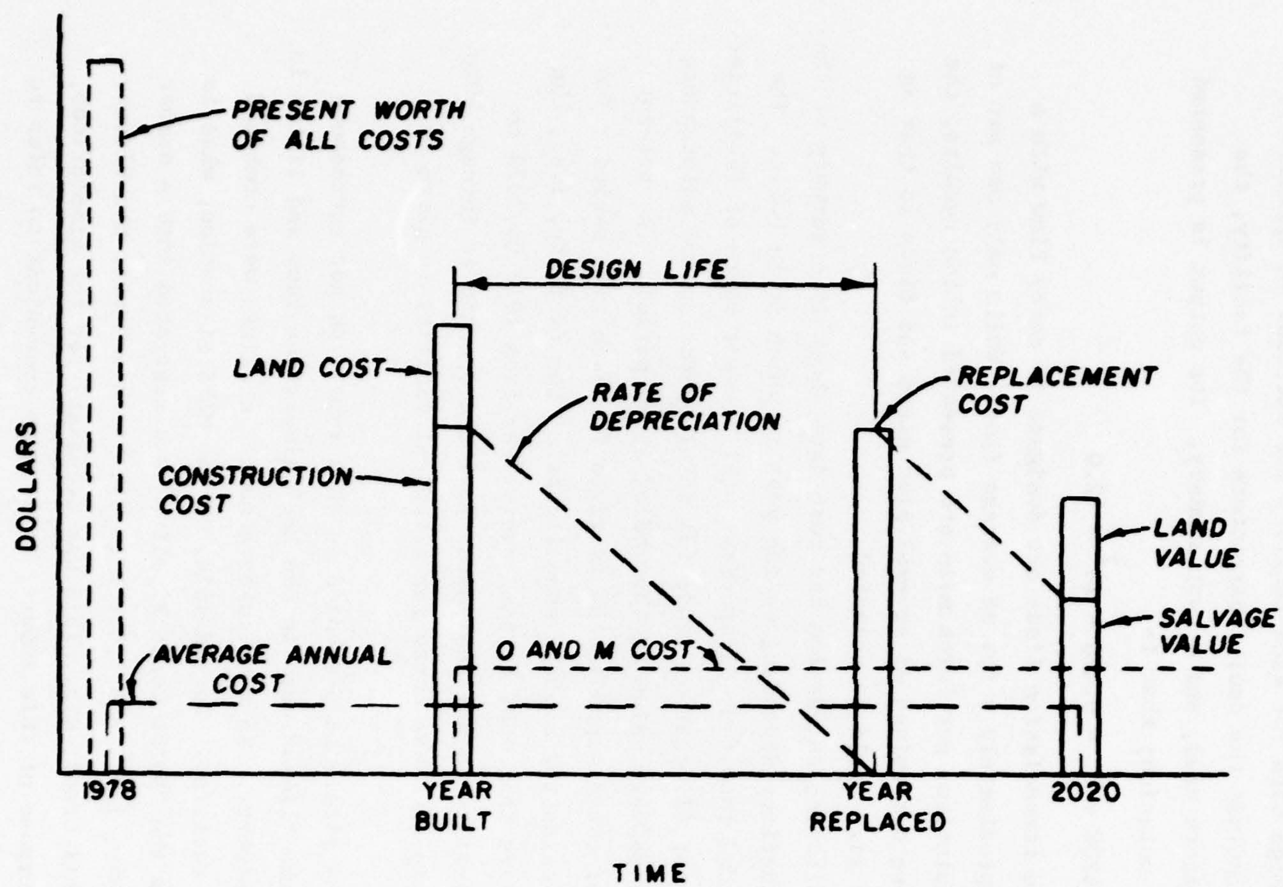


Figure 12. Graphical representation of costs versus time

though the facility may have only one name. For example, there are two different designs for the Pescadero Creek Reservoir; (1) if it is to store only Pescadero Creek water, and (2) if it is also to receive water pumped from the Pajaro River. In the former case the reservoir will have 12,200 acre-ft of storage while in the latter it will have 25,000 acre-ft. The two designs for the reservoir are included in Appendix F. In the plans presented in Appendix D, the user must be aware of which design is being used. Similarly, there are three alternative designs (and costs) for the North Coast Pipeline. If only Scott Creek Reservoir is built, the pipeline will consist of a 30-in. line from the reservoir to the coast and on to the Gordola Treatment Plant. If only Waddell Creek Reservoir is built, the line will consist of a 30-in. line from the reservoir to Gordola. If both are built, the North Coast Pipleine will consist of 30-in. lines from the reservoirs to a point on Scott Creek near the coast where the lines will join into a 45-in. line to the Gordola Treatment Plant.

126. In general, transmission lines from treatment facilities to service areas are not included in the analyses because the distribution system is not part of the system being analyzed. An exception to this is the line from the Aptos-Soquel Treatment Plant to the service area which is several miles long.

127. Since this report presents the costs of building and operating additional water supply facilities, the costs do not include continuing operation and maintenance of existing facilities. It is assumed that these facilities such as the Loch Lomond Reservoir and wellfields near Watsonville will continue to operate. Distribution system and administrative costs are not included.

128. In some of the MAPS simulation output for reservoir planning, references are made to alternative sites for the dam, e.g., Site A, Site B, etc. Since these refer to sites identified in the 1968 Master Plan,[4] that report should be consulted for the exact geographical location.

129. When a treatment facility is built in stages, e.g., Gordola or Aptos-Soquel Water Treatment Plants, the construction cost is

calculated as if the additional capacity consisted of a parallel plant; however, the operation and maintenance costs are calculated based on the total capacity of the plant.

130. The additional groundwater capacity for the San Lorenzo area of 10 mgd is divided into 10 wells with 1 mgd each. The figures for the cost versus year built are based on the construction of all wells at the same time. This represents a higher cost than if the construction of the wells are spread through time, but is done for simplicity of analysis.

Plan Summary for Santa Cruz

131. To evaluate the cost of a given alternative plan, add the costs of each component, which are presented in 1978 dollars. A listing of the costs of the components for each alternative plan is presented in Appendix D.

132. Costs cannot be compared exactly between plans with differing benefits because the figures presented include only the engineering costs and not the social and environmental benefits that will have a significant impact on the final decision. For example, it would be incorrect to compare the cost of plan S.2 with plan SAP.2 since the benefits of the SAP plan concern a much wider area.

133. The tables show that the most economical plans are those which rely on imported water and development of additional groundwater. The large reservoirs would be built as needed to supplement those sources. There are problems with this type of planning since the reservoir sites may not be available later. It is this type of trade-off that must be considered in the evaluation of the Stage 3 plan.

PART VI: PRELIMINARY DESIGN AND COST FOR MONTEREY

134. Most of the water used for all purposes in the Salinas Valley comes from groundwater sources. However, adequate information is lacking on the groundwater system in the Salinas-Monterey Bay area. The USGS[2] developed a finite element groundwater model that was used to describe the groundwater system for the 600-sq-mile area that extends from the vicinity of San Ardo northward to Monterey Bay. For the Monterey County area, the finite element groundwater model was used to determine the impact on groundwater levels of current and future pumping. It also provided information on the amount of pumping to prevent saltwater intrusion. The MAPS program is used only for design and cost information for the Monterey County area.

135. The facility planning for the Monterey Bay area was divided into six measures as shown in Table 2, which provided a basis for cost estimating through the year 2020. These measures were separated into component facilities for cost analysis in the MAPS program.

136. The average annual cost of the measures for the years 1980, 1990, 2000, and 2010 is presented in Table 3. The figures include construction, operation, and maintenance costs. A breakdown of the costs and design parameters used in computing the final cost is presented in Appendix G. A design summary of each facility or portion of facility is given, followed by a page giving the average annual costs of each component for different years of construction.

137. Power for the pumping stations represents a large portion of the average annual cost of some projects. Therefore, the costs can be significantly affected by the portion of the year in which the pumps are operating. For this cost estimate, it was assumed that the pumps would be operating one third of the year.

138. The costs in Table 3 do not include the distribution system for the Castroville system in measure MC and the East Side system in measure MD, as insufficient information was available to analyze the cost. The costs of the diversion canals from the Salinas River to the pumping stations were negligible and were omitted from Table 3. Three

Table 2

Measure for Monterey County

Measures*	Facilities
MA Facilities	ARROYO SECO DAM Reservoir
MB Facilities	CARMEL RIVER DAM Reservoir
MC Facilities	CASTROVILLE IRRIGATION PROJECT Force Main Pumping Station Open Channel Wellfields
MD Facilities	EAST SIDE PROJECT Force Main Pumping Station Open Channel Siphons Wellfields
MF Facilities	CARMEL WELLFIELD Wellfield
MG Facilities	RESERVOIR TUNNEL PROJECT Tunnel

* The names and data were supplied by the San Francisco District; MA = Monterey A, etc.

Table 3

Measure Cost Summary

Facility Name	Average Annual Cost in 10^3 \$/yr 1980	1990	2000	2010
MA				
Arroyo Seco Reservoir	1111	559	260	95
MB				
Carmel River Reservoir	6593	3318	1546	565
MC				
Castroville Pumping Station	249	122	54	20
Castroville Pumping Station to Reduced Pipeline	682	343	160	58
Reduced Pipeline to Castroville	89	45	21	8
Castroville Wellfields	122	59	27	10
Castroville Irrigation Project (total cost)	1142	569	262	96
MD				
East Side Canal, Part 1	148	74	34	12
East Side Canal, Part 2	32	16	7	3
East Side Canal, Part 3	30	15	7	2
East Side Canal, Part 4	21	10	5	2
East Side Wellfield	2945	1441	639	226
East Side Pumping Station to Canal	17	8	4	1
East Side Pumping Station	1886	922	409	144
East Side Siphons	46	23	10	4
East Side Project (total cost)	5125	2509	1115	394
MF				
Carmel Wellfield (180)	647	315	142	50
Carmel Wellfield (400)	667	325	146	52
Carmel Wellfield (900)	695	339	152	54
MG				
Nacimiento-San Antonio Tunnel	1516	763	356	130

designs were given for the Carmel wellfield depending on the aquifer from which water is drawn (180, 400, and 900 ft).

139. The design and economic parameters used to perform the cost evaluation in Monterey County are the same as used in Santa Cruz County. The reader is referred to Part V for a detailed discussion of these values.

REFERENCES

1. U. S. Army Engineer District, San Francisco, Salinas-Monterey Bay Area Urban Water Resources and Wastewater Management Study--Plan of Study, April 1975.

2. U. S. Geological Survey, Groundwater Model of Salinas Valley, Palo Alto, Calif. (report in preparation).

3. Earth Metrics Inc., Alternative Water Supply Plans for Monterey and Santa Cruz Counties, May 1978.

4. Office, Chief of Engineers, Engineer Regulation ER 1105-2-200, Multi-Objective Planning, Nov 1975.

5. Creegan & D'Angelo-McCandless (Joint Venture), Master Plan Development, Vol I: Planning Data, June 1968. Vol II: Details of Proposed Plan, February 1969.

6. U. S. Geological Survey, Water Resources Data for California, (various years).

7. Hickey, J. L., "Hydrogeologic Study of the Aptos-Soquel Area, Santa Cruz, Cal," USGS open-file report.

8. Engineering News-Record, May 1978, Vol 201, No. 5, McGraw-Hill, New York.

9. U. S. Environmental Protection Agency, Office of Water Program Operations, Municipal Construction Division, October 1978, Sewage Construction.

APPENDIX A: SIMULATION DATA

1. This appendix contains data used in the MAPS simulations of the study area. Tables A1 and A2, respectively, contain a listing of the nodes and links used and the MAPS modules which were assigned to them.

2. Table A3 contains the populations for each service area investigated. Tables A4 through A6 contain a breakdown of the major drainage basins according to the area drained by each headwater or stream reach. Table A7 identifies the nodes to which the service areas were assigned.

Table A1

Hydrologic Node Assignments

Node No.	Type of Node	Mod No.	Description
1	Reservoir	5	Loch Lomond
2	Reservoir	6	Zayante
3	Reservoir	7	Waterman Switch
4	Null	5	Diversion to Santa Cruz Supply Plant
5	Null	6	Diversion to Loch Lomond
6	Reservoir	1	Waddell A-Lower
7	Reservoir	2	Waddell B-Upper
8	Resrevoir	3	Scott Creek A & B - Lower
9	Reservoir	4	Scott Creek C - Upper
10	Null	1	San Vicente Diversion
11	Headwater	1	Spring-Liddell
12	Null	2	Laguna Creek Diversion
13	Null	3	Majors Creek Diversion
14	Reservoir	8	Glenwood
15	Reservoir	9	Upper Soquel Creek
16	Reservoir	10	Aptos Creek
17	Reservoir	11	Pescadero Creek
18	Reservoir	12	Corncob Creek
19	Null	11	Corralitos Creek Diversion
20	Null	7	Laguna Creek Pipe Junction
29	Reservoir	13	Kings Creek Site B
31	Null	7	Big Trees Gaging Station
33	Null	9	Main Br Soquel Creek Diversion
34	Null	10	Diversion to Aptos Laselva from Aptos Creek and Capitola
35	Headwater	2	Waddell Creek
36	Headwater	3	Scott Creek
37	Headwater	4	San Vicente Creek

(Continued)

(Sheet 1 of 3)

Table A1 (Continued)

Node No.	Type of Node	Mod No.	Description
38	Headwater	5	Laguna Creek
39	Headwater	6	Majors Creek
40	Headwater	7	San Lorenzo River
41	Headwater	8	Zayante Creek
42	Headwater	9	West Branch Soquel Creek
43	Headwater	10	Main Branch Soquel Creek
44	Headwater	11	Aptos Creek
45	Headwater	12	Corralitos Creek
46	Headwater	13	Pescadero Creek
47	Headwater	14	Pajaro River
48	Headwater	15	Corncob Creek
49	Null	12	Confluence of San Lorenzo and Newell Creek
50	Null	13	Confluence of San Lorenzo and Zayante
51	Null	14	Confluence of Corralitos Creek and Pajaro River
52	Null	15	Confluence of Pescadero Creek and Pajaro River
53	Null	16	Confluence of Corncob Creek and Pajaro River
54	Null	17	Confluence of West and Main Branches Soquel Creek
55	Null	18	Mouth of Waddell Creek
56	Null	19	Mouth of Scott Creek
57	Null	20	Mouth of San Vicente Creek
58	Null	21	Mouth of Laguna Creek
59	Null	22	Mouth of Majors Creek
60	Null	23	Mouth of San Lorenzo River
61	Null	24	Mouth of Soquel Creek
62	Null	25	Mouth of Aptos Creek

(Continued) (Sheet 2 of 3)

Table A1 (Concluded)

Node No.	Type of Node	Mod No.	Description
63	Null	26	Mouth of Pajaro River
64	Null	27	Liddell Spring Pipeline Junction
65	Null	28	Majors Creek Pipeline Junction
67	Headwater	16	Source Outside of Watershed
69	Headwater	17	Newell Creek
81	Null	40	Confluence of Kings Creek and San Lorenzo
83	Headwater	18	Kings Creek
84	Headwater	26	Boulder Creek
85	Headwater	27	Bear Creek
86	Null	41	Junction on San Lorenzo of Boulder and Bear Creeks
87	Reservoir	14	Boulder Creek
88	Reservoir	15	Bear Creek
91	Headwater	18	Baldwin Creek
92	Reservoir	16	Baldwin Creek

(Sheet 3 of 3)

Table A2

Hydrologic Link Numbers

Link From	Link To	Type	Mod No.	Description
				"Waddell Creek"
6	55	Stream	1	Lower Reservoir to Mouth
7	6	Stream	2	Upper Reservoir to Lower Reservoir
35	7	Stream	3	Headwater to Upper Reservoir
				"Scott Creek"
8	56	Stream	11	Lower Reservoir to Mouth
9	8	Stream	12	Upper Reservoir to Lower Reservoir
36	9	Stream	13	Headwater to Upper Reservoir
				"San Vicente Creek"
10	57	Stream	21	Diversion to Mouth
37	10	Stream	22	Headwater to Diversion
				"Laguna Creek"
12	58	Stream	31	Diversion to Mouth
38	12	Stream	32	Headwater to Diversion
				"Majors Creek"
13	59	Stream	41	Diversion to Mouth
39	13	Stream	42	Headwater to Diversion
				"Aptos Creek"
34	62	Stream	51	Diversion to Mouth
16	34	Stream	52	Reservoir to Diversion
44	16	Stream	53	Headwater to Reservoir
				"Soquel Creek"
33	61	Stream	61	Diversion to Mouth
54	33	Stream	62	Junction of West and Main Branch to Diversion
14	54	Stream	63	West Branch Reservoir to Junction
15	54	Stream	64	Main Branch Reservoir to Junction
43	15	Stream	65	Headwater to Reservoir
42	14	Stream	67	Headwater to Reservoir

(Continued)

(Sheet 1 of 3)

Table A2 (Continued)

Link From	Link To	Type	Mod No.	Description
				"San Lorenzo River"
4	60	Stream	71	Diversion (Santa Cruz) to Mouth
31	4	Stream	73	Big Tree to Diversion (Graham Hill)
5	31	Stream	74	Diversion (Loch Lomond) to Big Tree
50	5	Stream	75	Confluence with Zayante to Diversion (Loch Lomond)
49	50	Stream	76	Confluence (Loch Lomond) to Confluence (Zayante)
81	86	Stream	77	Confluence (Kings) to Junction of Bear and Boulder Creeks on San Lorenzo River
40	3	Stream	78	Headwater to Waterman Switch
3	81	Stream	79	Waterman Switch to Kings
86	49	Stream	80	Junction of Bear and Boulder Creeks on San Lorenzo River to Confluence (Newell Creek)
1	49	Stream	81	Reservoir (Loch Lomond) to Confluence with San Lorenzo River
87	86	Stream	82	Reservoir (Boulder) to Junction
84	87	Stream	83	Headwater to Reservoir (Boulder)
29	81	Stream	84	Reservoir (Kings) to San Lorenzo River
2	50	Stream	85	Reservoir (Zayante) to Confluence with San Lorenzo River
41	2	Stream	86	Headwater to Reservoir (Zayante)
83	29	Stream	87	Headwater (Kings) to San Lorenzo River
69	1	Stream	88	Headwater to Newell Creek
85	88	Stream	89	Headwater to Reservoir (Bear)
88	86	Stream	90	Reservoir (Bear) to Junction
				"Pajaro River"
53	63	Stream	91	Confluence with Corncob Creek to Mouth
51	53	Stream	92	Confluence with Corralitos Creek to Confluence with Corncob Creek
47	52	Stream	93	Headwater to Confluence with Pescadero Creek

(Continued)

(Sheet 2 of 3)

Table A2 (Concluded)

Link From	Link To	Type	Mod No.	Description
				"Corncob Creek"
18	53	Stream	96	Reservoir to Confluence with Pagaro River
48	18	Stream	97	Headwater to Reservoir
				"Pescadero Creek"
52	51	Stream	101	Confluence with Corralitos Creek to Pescadero Creek
17	52	Stream	102	Pescadero Reservoir to Confluence with Pajaro River
46	17	Stream	103	Headwater to Reservoir
				"Corralitos Creek"
19	51	Stream	106	Diversion to Confluence with Pescadero Creek
45	19	Stream	107	Headwater to Diversion
				"Baldwin Creek"
91	92	Stream	110	Headwater to Dam

(Sheet 3 of 3)

Table A3

Service Area Data

Projection	Population Served	Average Usage mgd
	Service Area 1 Santa Cruz and Pasatiempo	
Low		
1980	47,560	10.0
1990	57,720	12.1
2000	67,890	14.3
2010	78,040	16.4
2020	88,170	18.5
Base		
1980	51,100	10.7
1990	67,760	14.2
2000	83,100	17.4
2010	100,000	21.0
2020	115,900	24.3
High		
1980	55,090	11.6
1990	77,300	16.2
2000	99,520	20.4
2010	121,730	25.6
2020	143,940	30.2

Per Capita Usage = 210 GPCD*

(Continued)

* GPCD = gallons per capita per day

(Sheet 1 of 5)

Table A3 (Continued)

Projection	Population Served	Average Usage mgd
	Service Area 2 San Lorenzo Valley	
Low		
1980	0	0.0
1990	13,670	1.91
2000	16,080	2.25
2010	18,490	2.59
2020	20,800	2.91
Base		
1980	0	0.0
1990	15,920	2.23
2000	19,710	2.76
2010	23,500	3.29
2020	27,290	3.82
High		
1980	0	0.0
1990	18,320	2.56
2000	23,580	3.30
2010	28,840	4.04
2020	34.100	4.77

Per Capita Usage = 140 GPCD

(Continued)

(Sheet 2 of 5)

Table A3 (Continued)

Projection	Population Served	Average Usage mgd
	Service Area 3 Scott Valley	
Low		
1980	8,520	1.37
1990	10,340	1.66
2000	12,160	1.96
2010	13,990	2.25
2020	15,810	2.55
Base		
1980	9,150	1.47
1990	12,040	1.94
2000	14,910	2.40
2010	17,780	2.86
2020	20,640	3.32
High		
1980	9,870	1.59
1990	13,850	2.23
2000	17,840	2.87
2010	21,820	3.51
2020	25,800	4.15

Per Capita Usage = 161 GPCD

(Continued)

Table A3 (Continued)

Projection		Population Served	Average Usage mgd
		Service Area 4 **Soquel, Capitola, Aptos**	
Low			
	1980	54,790	7.62
	1990	66,510	9.24
	2000	78,220	10.87
	2010	89,930	12.39
	2020	101,651	14.13
Base			
	1980	59,000	8.20
	1990	77,440	10.76
	2000	95,880	13.33
	2010	114,310	15.89
	2020	132,750	18.45
High	1980	63,490	8.83
	1990	89,090	12.38
	2000	114,680	15.94
	2010	140,280	19.50
	2020	165,880	23.06

Per Capita Usage = 139 GPCD

(Continued)

(Sheet 4 of 5)

Table A3 (Concluded)

Projection		Population Served	Average Usage mgd
		Service Area Lower Pajaro (Watsonville)	
Low			
	1980	46,160	6.69
	1990	55,530	8.05
	2000	64,900	9.41
	2010	74,280	10.77
	2020	83,650	12.13
Base			
	1980	49,660	7.20
	1990	64,600	9.37
	2000	79,550	11.53
	2010	94,500	13.70
	2020	104,450	15.87
High			
	1980	52,920	7.67
	1990	73,070	10.60
	2000	93,230	13.52
	2010	113,390	16.44
	2020	133,550	19.36

Per Capita Usage = 145 GPCD

(Sheet 5 of 5)

Table A4

San Lorenzo Drainage Area Breakdown

Name	Node	Mod	Area sq mi	
	Headwater			
San Lorenzo	40	7	6.5	
Kings	83	18	7.0	
Newell	69	17	8.2	
Zayante	41	8	9.5	
Bear	84	27	11.7	
Boulder	84	26	7.5	50.4
	Stream			
Graham Hill - Mouth	4-60	71	18.	
Big Tree - Graham Hill	31-4	73	7.	
Felton - Big Tree	5-31	74	5.	
Zayante Cr. - Felton	50-5	75	0.0	
Newell Cr. - Zayante Cr.	49-50	76	8.3	
Kings Cr. - Bear Cr.	81-86	77	4.3	
Head - Waterman	40-3	78	0.0	
Waterman - Kings Cr.	3-81	79	5.	
Bear Cr. - Newell Cr.	86-49	80	10.2	
Loch Lomond - San Lorenzo	1-49	81	1.4	
Boulder Dam - San Lorenzo	87-06	82	3.8	
Head - Boulder Dam	84-87	83	0.0	
Kings Dam - San Lorenzo	29-81	84	3.	
Zayante Dam - San Lorenzo	2-50	85	15.2	
Head - Zayante Dam	41-2	86	0.0	
Head - Kings Dam	83-29	87	0.0	
Head - Loch Lomond	69-1	88	0.0	
Head - Bear Dam	85-88	89	0.0	
Bear Dam - San Lorenzo	88-86	90	4.5	85.7
			Total	136.1

Table A5

Aptos-Soquel Drainage Area Breakdown

Name	Node	Mod	Area sq mi	
	Headwater			
Soquel	43	10	13.7	
West Branch	47	9	7.8	21.5
Aptos	44	11	10.3	10.3
	Stream			
Diversion - Mouth	33-61	61	2.2	
Confluence - Diversion	54-33	62	8.9	
Dam, West Branch - Confluence	14-54	63	4.5	
Dam, Soquel - Confluence	15-54	64	5.3	
Head - Dam, Soquel	43-15	65	0.0	
Head - Dam, West Branch	42-14	67	0.0	20.9
Aptos				
Diversion - Mouth	34-62	51	9.0	
Aptos Dam - Diversion	16-34	52	15.3	
Head - Aptos Dam	44-16	53	0.0	24.3
			Total	77.0

Table A6

Pajaro Drainage Area

Name	Node	Mod	Area sq mi	
	Headwater			
Pajaro	47	14	1175.0	
Pascadero	46	13	9.5	
Corralitos	45	12	27.8	
Corncob	48	15	1.0	1213.3
	Stream			
Corncob - Mouth	53-63	91	27.0	
Watsonville - Corncob	51-53	92	0.0	
Head - Pescadero	47-52	93	0.0	
Corncob Dam - Pajaro	18-53	96	0.0	
Head - Corncob Dam	48-18	97	0.0	
Pescadero - Salsipuedos	52-51	101	29.0	
Pescadero Dam - Pajaro	17-52	102	1.0	
Head - Pescadero Dam	13-17	103	0.0	
Diverson on Corralitos-Pajaro	19-51	106	29.7	
Head - Diversion on Corralitos	45-19	107	0.0	86.7
			Total	1300.0

Table A7

Service Area Assignments

Node No.	Mod No.	Service Area
21	1	Santa Cruz - Pasatiempo
22	2	San Lorenzo Valley
23	3	Scott Valley
24	4	Aptos-Soquel-Capitola
25	5	Watsonville
26	6	Export of water from Santa Cruz Co.

APPENDIX B: HEADWATER DATA

This appendix contains a great deal of data that would not be of interest to most readers of the report. A limited number of copies of this appendix are available and may be obtained by contacting:

U. S. Army Engineer Waterways Experiment Station
ATTN: Thomas M. Walski (WESEE)
P. O. Box 631
Vicksburg, Miss. 39180

Commercial telephone: 601/636-3111, Ext. 3931
FTS: 542-3931

APPENDIX C: STREAM REACH DATA

1. The following appendix contains essential information used to characterize the stream reach for input to the MAPS program. The stream reach numbers refer to the values in boxes in Figure 3 of the text.

2. The column labeled "Headwater Control" refers to the headwater with similar runoff values in inches/year as the stream reach. The "Incremental Area" is the area drained by the stream reach not including upstream reaches or headwaters. In some cases the value is zero since all of the drainage area above the reservoir or diversion was accounted for in the headwater node data.

Stream Reaches	Stream Reach Mod No.	Head-water Control Mod No.	Incre-mental Area square miles
Waddell Creek			
Reservoir site A to mouth	1	2	
Reservoir site B to reservoir site A	2	2	15.4
Headwater to reservoir site B	3	2	0.0
Scott Creek			
Reservoir site B to mouth	11	3	1.8
Reservoir site C to reservoir site B	12	3	16.0
Headwater to reservoir site C	13	3	0.0
San Vicente Creek			
Diversion site to mouth	21	4	2.0
Headwater to diversion site	22	4	9.5
Laguna Creek			
Diversion site to mouth	31	5	2.93
Headwater to diversion site	32	5	0.0
Majors Creek			
Diversion site to mouth	41	6	.24
Headwater to diversion site	42	6	0.0
Aptos Creek			
Diversion site to mouth	51	11	14.4
Reservoir site to diversion site	52	11	9.92
Headwater to reservoir	53	11	0.0
Soquel Creek			
Diversion site to mouth	61	10	2.2
Junction of west and main branches of Soquel to diversion site	62	10	8.9
Reservoir site B on west branch to junction of west and main branches of Soquel Creek	63	9	4.5
Reservoir site B on main branch to junction of west and main branches	64	10	0.0
Main branch headwater to reservoir site B on main branch of Soquel Creek	65	10	0.0
West branch headwater to reservoir site B on west branch of Soquel Creek	67	9	0.0

Stream Reaches	Stream Reach Mod No.	Head-water Control Mod No.	Incre-mental Area square miles
San Lorenzo River			
Graham Hill intake to mouth	71	8	18.0
Big Tree gaging station to Graham Hill intake	73	8	7.0
Diversion at Felton to Big Tree gaging station	74	8	5.0
Confluence with Zayante Creek to diversion at Felton	75	8	0.0
Confluence with Newell Creek to confluence with Zayante Creek	76	8	8.3
Confluence with Kings Creek to confluence with Boulder and Bear Creeks	77	18	4.3
Headwater of San Lorenzo River to reser-voir at Waterman Switch	78	7	0.0
Reservoir at Waterman Switch to confluence with Kings Creek	79	7	5.0
Confluence with Boulder and Bear Creeks to confluence of Newell Creek	80		
Reservoir on Newell Creek to confluence with Newell Creek on San Lorenzo River	81	17	1.4
Boulder Creek reservoir to junction of Bear and Boulder Creeks on San Lorenzo River	82	26	3.8
Headwater on Boulder Creek to Boulder Creek reservoir	83	26	0.0
Reservoir on Kings Creek to confluence with Kings Creek on San Lorenzo River	84	18	3.0
Reservoir on Zayante Creek to confluence with Zayante on San Lorenzo River	85	8	15.2
Headwater on Zayante Creek to reservoir on Zayante Creek	86	8	0.0
Headwater on Kings Creek to reservoir on Kings Creek	87	18	0.0
Headwater on Newell Creek to reservoir site on Newell Creek	88	17	0.0
Headwater on Bear Creek to reservoir site on Bear Creek	89	27	0.0
Reservoir site on Bear Creek to junction of Boulder and Bear Creeks on San Lorenzo River	90	27	4.5

Stream Reaches	Stream Reach Mod No.	Head-water Control Mod No.	Incre-mental Area square miles
Pajaro River			
Confluence with Corncob Creek to mouth	91	12	27.0
Confluence with Salsipuedes Creek to confluence with Corncob Creek	92	12	0.0
Headwater on Pajaro River to confluence with Pescadero Creek	93	14	0.0
Corncob Creek			
Reservoir on Corncob Creek to confluence with Pajaro River	96	15	0.0
Headwater on Corncob Creek to reservoir on Corncob Creek	97	15	0.0
Pescadero Creek			
Confluence with Corralitos Creek to confluence with Pescadero Creek	101	12	29.0
Reservoir on Pescadero Creek to confluence with Pajaro River	102	13	1.0
Headwater on Pescadero Creek to reservoir on Pescadero Creek	103	13	0.0
Corralitos Creek			
Diversion at gaging station to confluence with Salsipuedes Creek on Pajaro River	106	12	29.7
Headwater on Corralitos Creek to diversion at gaging station	107	12	0.0
Baldwin Creek			
Headwater on Baldwin Creek to reservoir on Baldwin Creek	110	19	2.0

APPENDIX D: SUMMARY OF INTERMEDIATE PLANS

1. This appendix gives a summary of costs for each Stage 2 alternative, intermediate water supply plans for Santa Cruz County. It consists of a cost summary for all plans and a table giving the components of the plan to be built or upgraded, the year in which it is to be completed, the final capacity of the facility, and a reference to the figures in which the plan is illustrated.

2. Only the major pipelines are shown. It is assumed that distribution systems are provided for the San Lorenzo Valley, Scott Valley, and Zayante Valley.

3. The value for the "year completed" for each facility is based on the assumption that the base population projection will hold. The values must be corrected if a higher or lower population projection proves to be true. The average annual cost, expressed as a function of "year completed," for each facility is shown in Appendix E.

4. The figures show the networks for the S, A, and P plans. The networks for the SA and SAP plans can be developed by combining the figures for the appropriate S, A, and P plans. No tables are provided for Plans S.0, S.51, A.0, P.0, SA.0, and SAP.0 since they represent "do nothing" plans with no reservoir or major pipeline construction. (Plans S.0 and S.51 are shown in Figure D1.)

5. More detailed design printouts are given for Santa Cruz County in Appendix F and for Monterey County in Appendix G.

Cost Summary of S Plans

Plans	Cost, 10^3 \$
S.1	2804
S.2	2723
S.3	2729
S.4	2567
S.5	3046
S.6	2785
S.7	2762
S.8	3119
S.9	3021
S.52	857
S.53	874
S.54	850
S.55	1032
S.56	1109
S.57	1147

Cost Summary of A Plans

Plans	Cost, 10^3 \$
A.1	761
A.2	694
A.3	318
A.4	309
A.5	451
A.6	774

Cost Summary of P Plans

Plans	Cost, 10^3 \$
P.3	1548
P.4	1591

Cost Summary of SA Plans

Plans	Cost, 10^3 \$
SA.1	1140
SA.2	1161
SA.3	1089
SA.4	1443
SA.5	1354
SA.6	1189
SA.7	1100
SA.8	1074
SA.9	1115
SA.10	1206

Cost Summary of SAP Plans

Plans	Cost, 10^3 \$
SAP.1	1985
SAP.2	714
SAP.3	515
SAP.4	519

PLAN S.1

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1980	1305
ZAYANTE-FELTON PIPELINE	10 MGD	1980	99
FELTON PUMP STATION*	20 MGD	1980	239
FELTON TREATMENT PLANT	5 MGD	1980	391
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1997	347
NORTH COAST PIPELINE	20 MGD	1997	114
GORDOLA TREATMENT PLANT	10 MGD	1997	244
SAN VICENTE DIVERSION	10 MGD	1997	33
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2018	24
GORDOLA TREATMENT PLANT*	20 MGD	2018	8
			2804

Plan Shown in Figure D2

PLAN S.2

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1980	1305
ZAYANTE-FELTON PIPELINE	10 MGD	1980	99
FELTON PUMP STATION*	20 MGD	1980	239
FELTON TREATMENT PLANT	5 MGD	1980	391
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1997	347
NORTH COAST PIPELINE	10 MGD	1997	57
GORDOLA TREATMENT PLANT	10 MGD	1997	244
SAN VICENTE DIVERSION		1997	33
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2018	7
BALDWIN CREEK-GORDOLA PIPELINE	5 MGD	2018	1
			2723

PLAN SHOWN IN FIGURE D-3

* Refers to upgrade of existing facility.

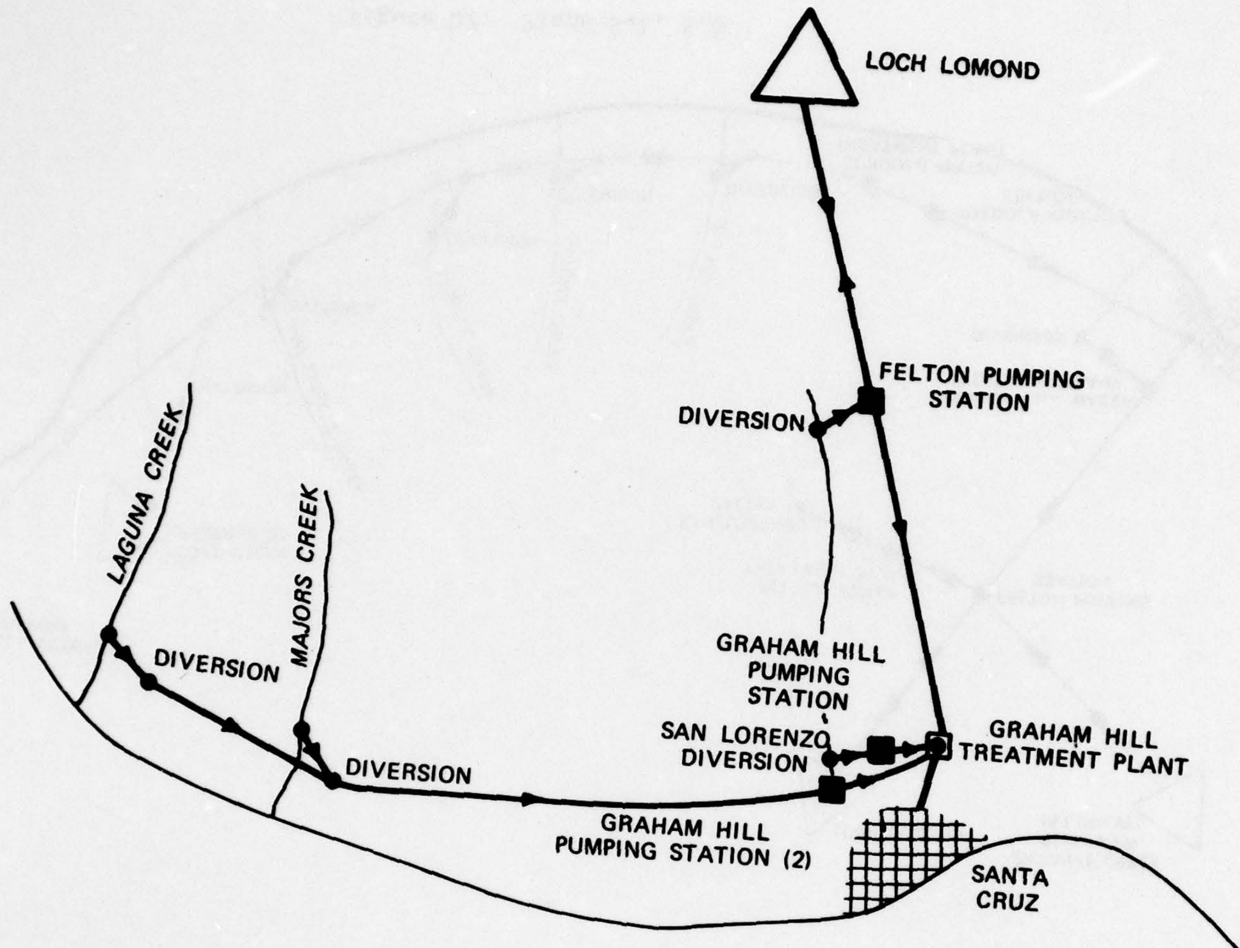


Figure D1. Plans S.0, S.51

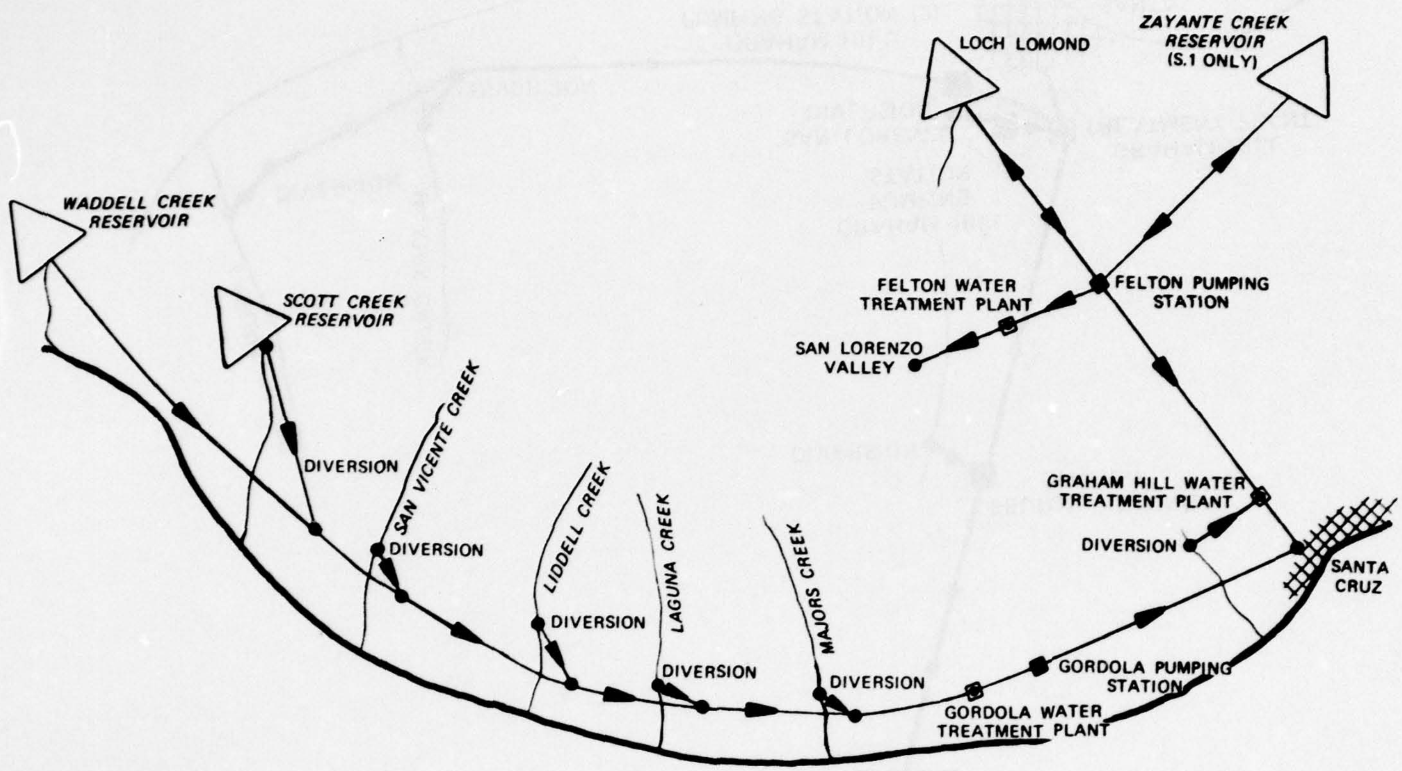


Figure D2. Plans S.1, S.8

PLAN S.3

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1980	1305
ZAYANTE-FELTON PIPELINE	10 MGD	1980	99
FELTON PUMP STATION*	20 MGD	1980	239
FELTON TREATMENT PLANT	5 MGD	1980	391
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1997	347
NORTH COAST PIPELINE	10 MGD	1997	57
GORDOLA TREATMENT PLANT	10 MGD	1997	244
SAN VICENTE DIVERSION		1997	33
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	2018	8
UPPER SAN LORENZO PLANT	5 MGD	2018	6
			2729

PLAN SHOWN IN FIGURE D4

PLAN S.4

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1980	1305
ZAYANTE-FELTON PIPELINE	10 MGD	1980	99
FELTON PUMP STATION	20 MGD	1980	239
GORDOLA TREATMENT PLANT*	10 MGD	1997	244
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	1997	131
BALDWIN CREEK-GORDOLA PIPELINE	5 MGD	1997	2
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	2000	112
UPPER SAN LORENZO PLANT	5 MGD	2000	81
KINGS CREEK RESERVOIR	8000 ACRE-FT	2005	183
BEAR CREEK RESERVOIR	12800 ACRE-FT	2010	171
			2567

PLAN SHOWN IN FIGURE D3

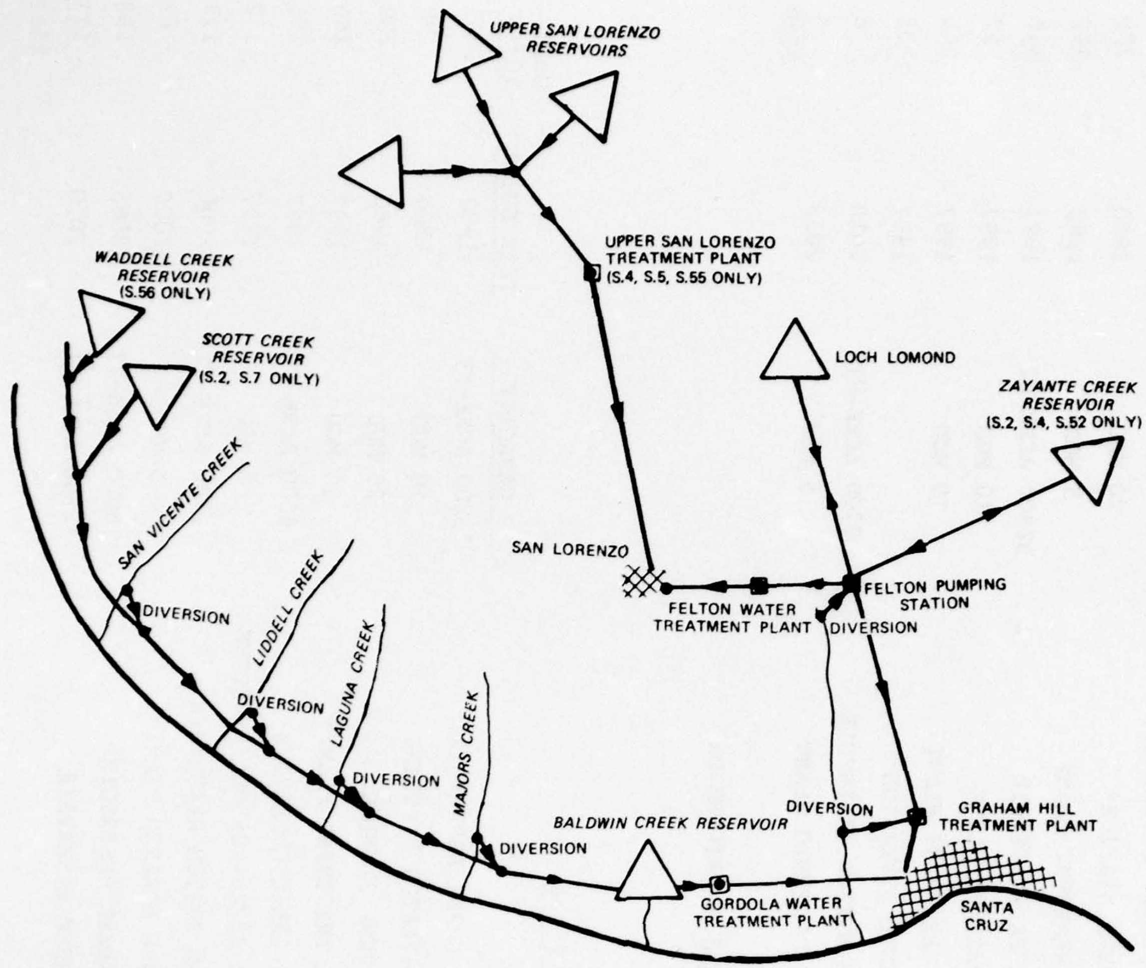


Figure D3. Plans S.2, S.4, S.5, S.7, S.52, S.55, S.56

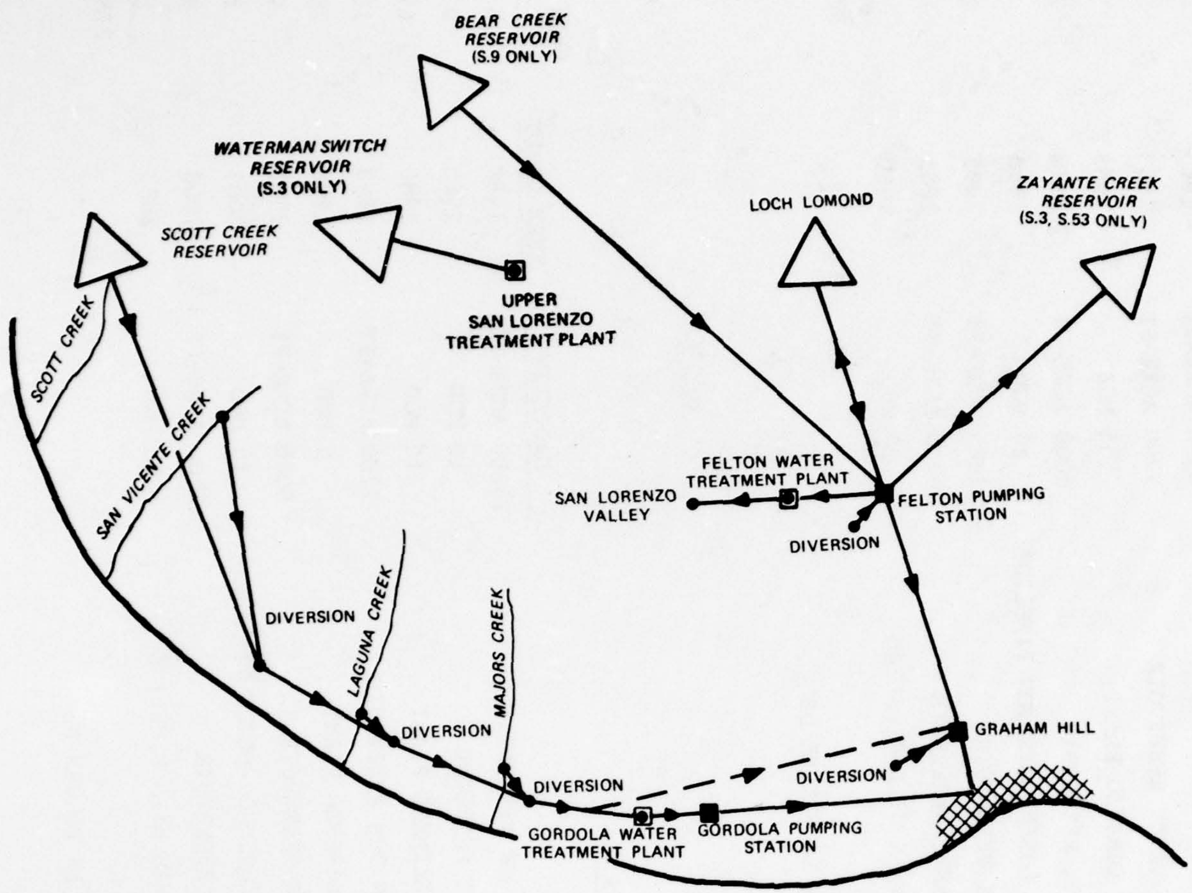


Figure D4. Plans S.3, S.9, S.53, S.57

PLAN S.5

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
GORDOLA TREATMENT PLANT	10 MGD	1980	672
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	1980	419
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	1983	874
UPPER SAN LORENZO PLANT	5 MGD	1983	317
KINGS CREEK RESERVOIR	8000 ACRE-FT	1990	250
UPPER SAN LORENZO-FELTON PIPELINE	10 MGD	1990	48
EEAR CREEK RESERVOIR	12800 ACRE-FT	1995	269
BOULDER CREEK RESERVOIR	10200 ACRE-FT	2005	154
FELTON-GRAHAM HILL PIPELINE	10 MGD	1990	43
			3046

PLAN SHOWN IN FIGURE D3

PLAN S.6

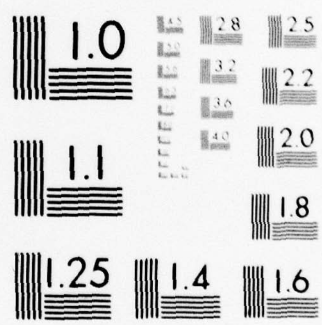
FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
WADDELL CREEK RESERVOIR	28800 ACRE-FT	1980	1434
NORTH COAST PIPELINE	10 MGD	1980	231
GORDOLA TREATMENT PLANT	10 MGD	1980	672
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	1998	137
UPPER SAN LORENZO PLANT	5 MGD	1998	101
KINGS CREEK RESERVOIR	8000 ACRE-FT	2003	93
UPPER SAN LORENZO-FELTON PIPELINE	10 MGD	2003	18
BEAR CREEK RESERVOIR	12800 ACRE-FT	2008	83
FELTON-GRAHAM HILL PIPELINE	10 MGD	2003	16
			2785

PLAN SHOWN IN FIGURE D5

AD-A074 536 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 13/2
APPLICATION OF MAPS TO THE SALINAS-MONTEREY URBAN STUDY.(U)
AUG 79 T M WALSKI, A C GIBSON
UNCLASSIFIED WES/EL-79-4 NL

2 OF 2
AD A074536

END
DATE FILMED
10-79
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

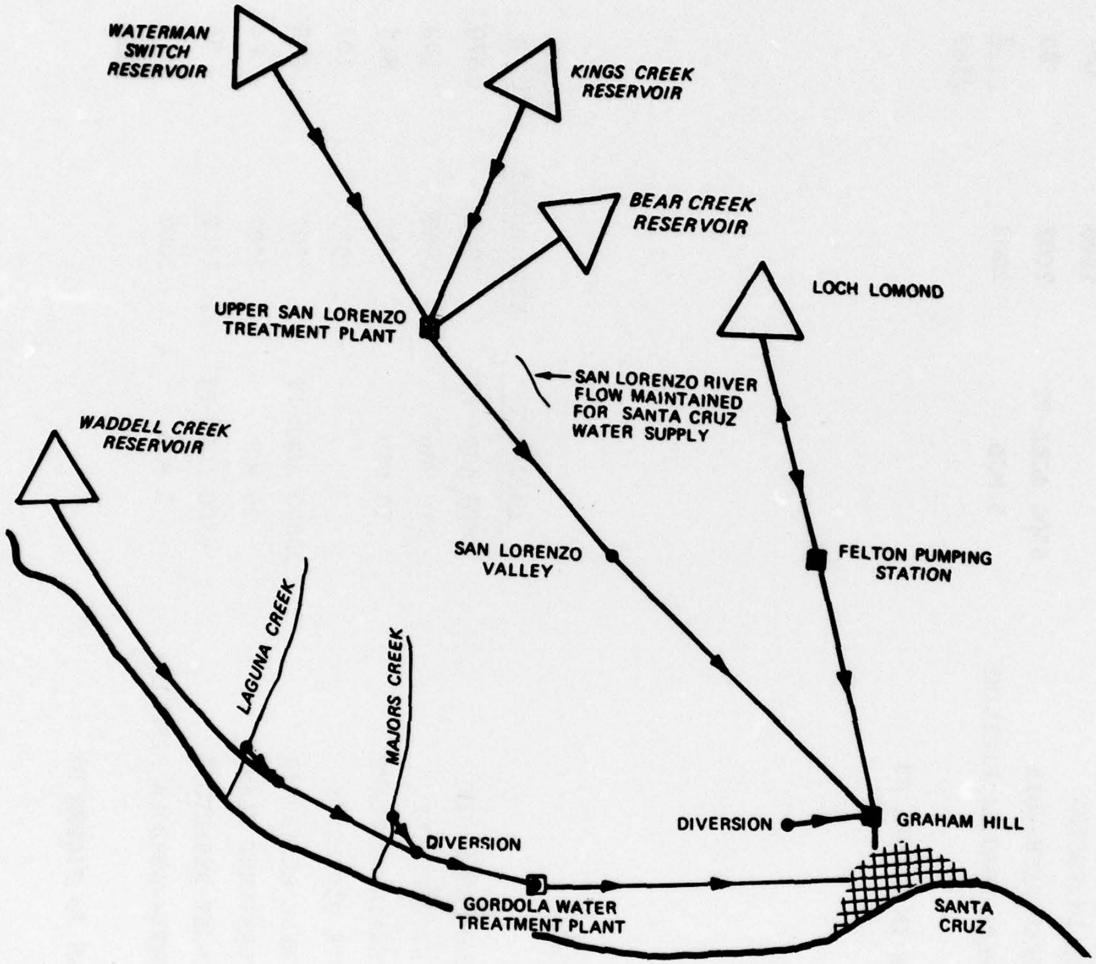


Figure D5. Plan S.6

PLAN S.7

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1980	1570
NORTH COAST PIPELINE	10 MGD	1980	183
GORDOLA TREATMENT PLANT	10 MGD	1980	815
SAN VICENTE DIVERSION		1980	107
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2002	85
BALDWIN CREEK-GORDOLA PIPELINE	5 MGD	2002	2
			2762

PLAN SHOWN IN FIGURE D3

PLAN S.8

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1980	1570
NORTH COAST PIPELINE	10 MGD	1980	183
GORDOLA TREATMENT PLANT	10 MGD	1980	815
SAN VICENTE DIVERSION		1980	107
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2002	293
GORDOLA TREATMENT PLANT*	20 MGD	2002	64
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2002	85
BALDWIN CREEK-GORDOLA PIPELINE	5 MGD	2002	2
			3119

PLAN SHOWN IN FIGURE D2

PLAN S.9

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
Scott Creek Reservoir	32800 acre-ft	1980	1570
North Coast Pipeline	10 MGD	1980	183
Gordola Treatment Plant	10 MGD	1980	815
San Vicente Diversion		1980	107
Bear Creek Reservoir	12800 Acre-ft	2002	149
Plan shown in Figure D4			2824

PLAN S.52

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
San Lorenzo Wellfield	10 MGD	1980	138
Groundwater Treatment Plant	10 MGD	1980	88
Zayante Creek Reservoir	25800 Acre-ft	1995	481
Zayante-Felton Pipeline	10 MGD	1995	37
Felton Pump Station	20 MGD	1995	85
Gordola Treatment Plant	10 MGD	2017	18
Baldwin Creek Reservoir	6500 Acre-ft	2017	10
Plan shown in Figure D3			857

PLAN S.53

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
San Lorenzo Wellfield	10 MGD	1980	138
Groundwater Treatment Plant	10 MGD	1980	88
Zayante Creek Reservoir	25800 Acre-ft	1995	481
Za ante-Felton Pipeline	10 MGD	1995	37
Felton Pump Station	20 MGD	1995	85
Scott Creek Reservoir	24 MGD	1995	27
North Coast Pipeline	32800 Acre-ft	2017	5
Gordola Treatment Plant	10 MGD	2017	12
San Vicente Diversion	10 MGD	2017	1
Plan shown in Figure D4			874

PLAN S.54

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
San Lorenzo Wellfield	10 MGD	1980	138
Groundwater Treatment Plant	10 MGD	1980	88
Zayante Creek Reservoir	25800 Acre-ft	1995	481
Zayante-Felton Pipeline	10 MGD	1995	37
Felton Pump Stations	20 MGD	1995	85
Waterman Switch Reservoir	7700 Acre-ft	2017	12
Upper San Lorenzo Plant	5 MGD	2017	9
Plan shown in Figure D6			850

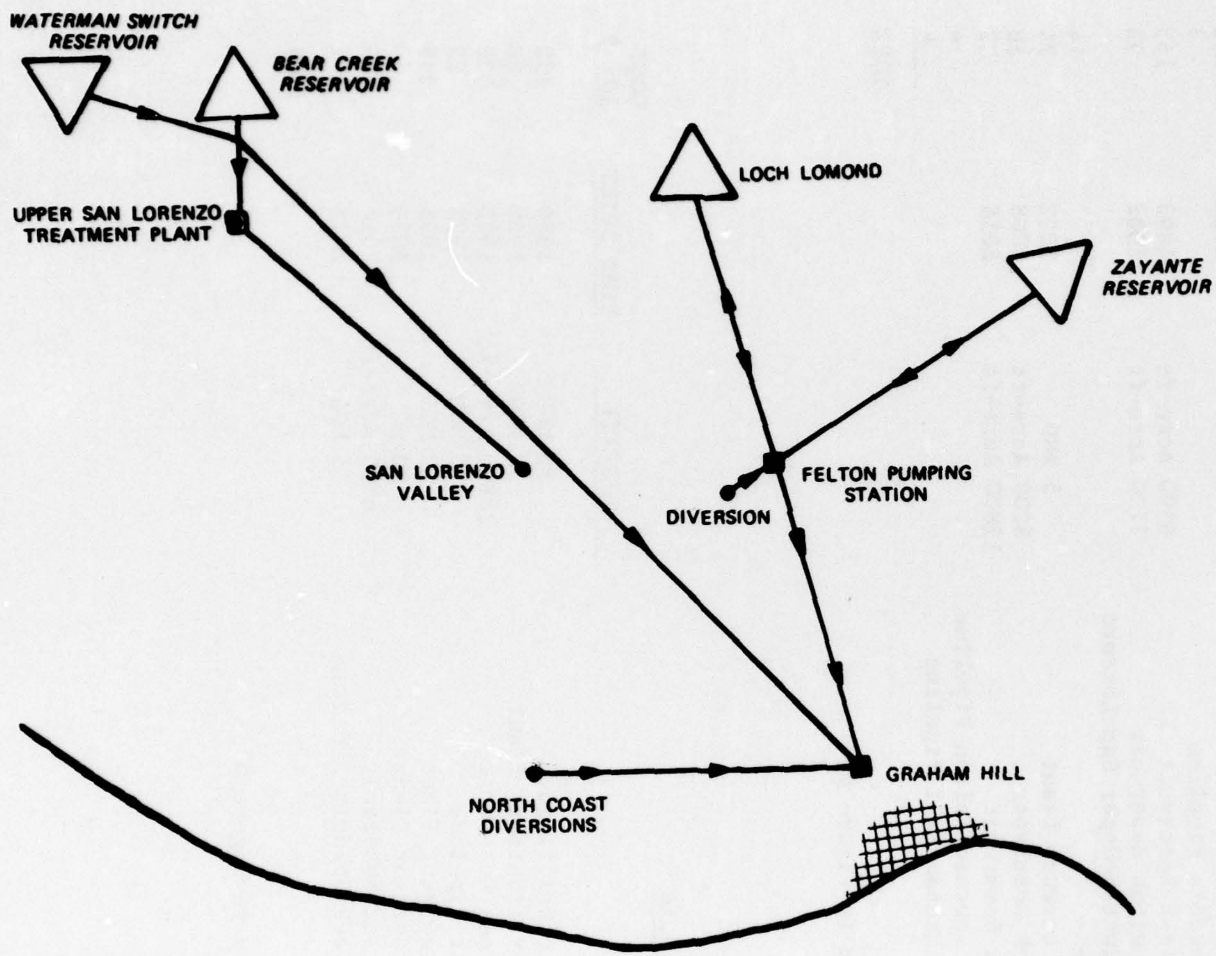


Figure D6. Plan S.54

PLAN S.55

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
San Lorenzo Wellfield	10 MGD	1980	138
Groundwater Treatment Plant	10 MGD	1980	88
Gordola Treatment Plant	20 MGD	1995	364
Baldwin-Gordola Pipeline			3
Baldwin Creek Reservoir	6500 Acre-ft	1995	155
Waterman Switch Reservoir	7700 Acre-ft	2002	98
Waterman Switch-Upper San Lorenzo Pipeline			14
Upper San Lorenzo Plant	5 MGD	2002	74
Kings Creek Reservoir	8000 Acre-ft	2008	58
Bear Creek Reservoir	12800 Acre-ft	2015	32
Upper San Lorenzo-Felton Pipeline			4
Felton to Graham Hill Pipeline			4
			1032

Plan shown in Figure D3

PLAN S.56

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
San Lorenzo Wellfield	10 MGD	1980	138
Groundwater Treatment Plant	10 MGD	1980	88
Waddell Creek Reservoir	28800 Acre-ft	1995	530
North Coast Pipeline	10 MGD	1995	85
Gordola Treatment Plant	10 MGD	1995	239
Gordola Treatment Plant*	20 MGD	2016	14
Baldwin Creek Reservoir	6500 Acre-ft	2016	14
Baldwin Creek-Gordola Pipeline	5 MGD	2016	1
			1109

Plan shown in Figure D3

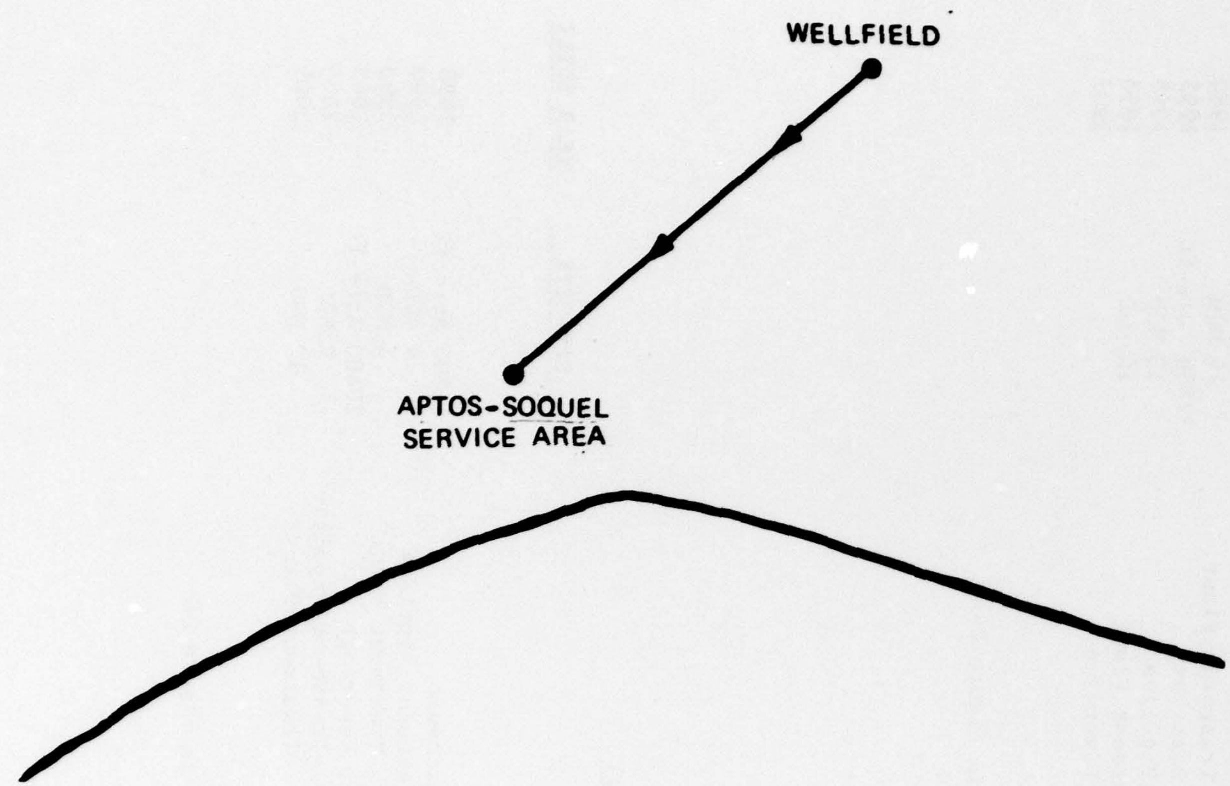


Figure D7. Plan A.0

PLAN S.57

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
San Lorenzo Wellfield	10 MGD	1980	138
Groundwater Treatment Plant	10 MGD	1980	88
Scott Creek Reservoir	32800 Acre-ft	1995	579
North Coast Pipeline	10 MGD	1995	85
Gordola Treatment Plant	10 MGD	1995	239
San Vicente Diversion		1995	18
			1147

Plan shown in Figure D4

PLAN A.1

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
Glenwood Reservoir	11800 Acre-ft	1990	345
Glenwood-Treatment Pipeline	4 MGD	1990	30
Treatment Plant	4 MGD	1990	163
Upper Soquel Reservoir	20400 Acre-ft	2005	172
Upper Soquel-Treatment Pipeline	7 MGD	2005	10
Treatment Plant*	12 MGD	2005	41
			761

Plan shown in Figure D8

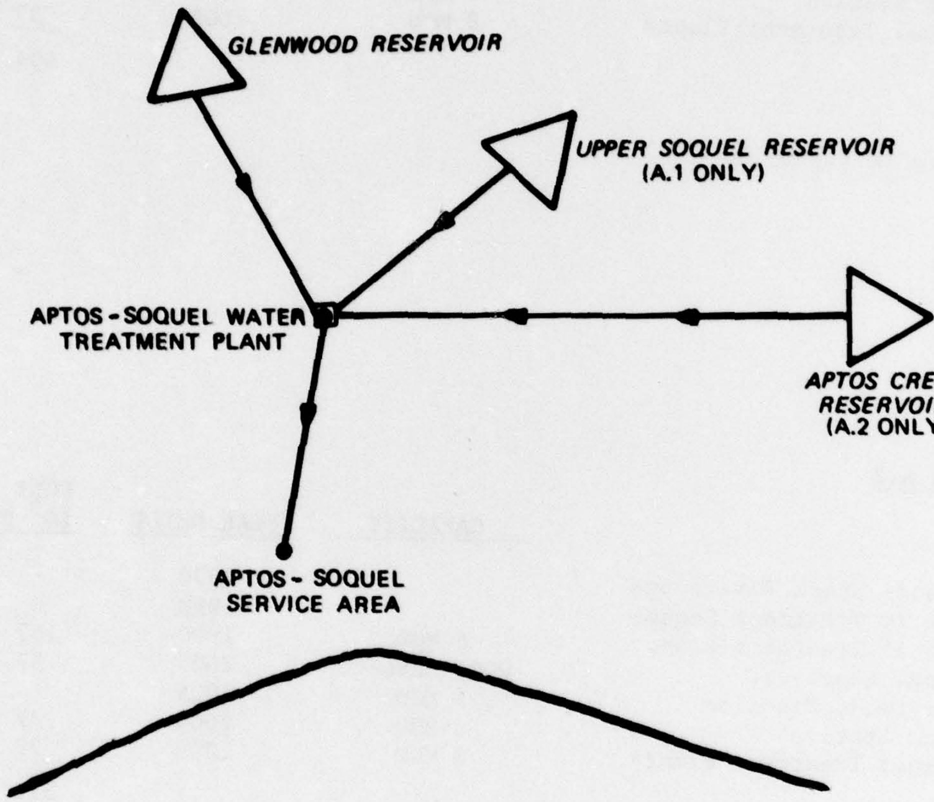


Figure D8. Plans A.1, A.2

PLAN A.2

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
Glenwood Reservoir	11800 Acre-ft	1990	345
Glenwood-Treatment Pipeline	4 MGD	1990	30
Aptos-Soquel Treatment Plant	4 MGD	1990	163
Aptos Creek Reservoir	9000 Acre-ft	2005	88
Aptos-Treatment Pipeline	4 MGD	2005	4
Aptos Pump Station	4 MGD	2005	37
Aptos-Soquel Treatment Plant*	8 MGD	2005	27
			694

Plan shown in Figure D8

PLAN A.3

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
Aptos-Soquel Creek Diversions		1990	-
Diversion to Treatment Soquel		1990	-
Aptos-Soquel Treatment Plant	4 MGD	1990	163
Aptos Creek Reservoir	9000 Acre-ft	2005	87
Aptos-Treatment Pipeline	4 MGD	2005	4
Aptos Pump Station	4 MGD	2005	37
Aptos-Soquel Treatment Plant*	8 MGD	2005	27
			318

Plan shown in Figure D9

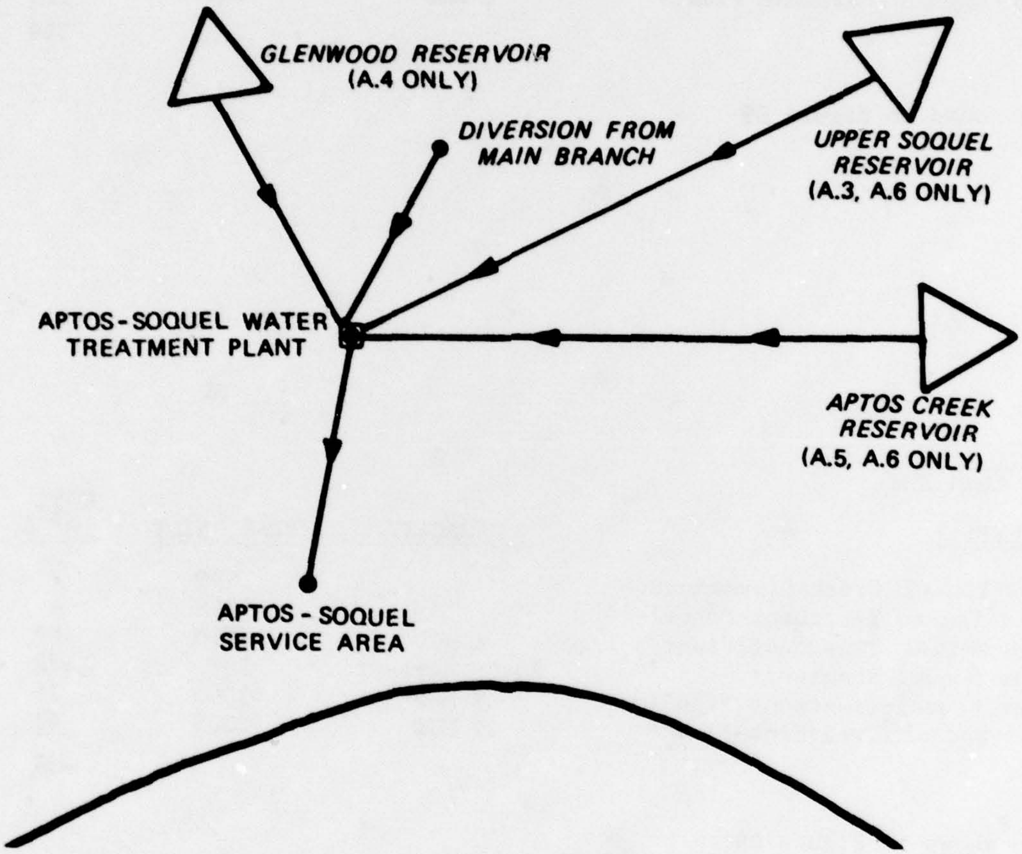


Figure D9. Plans A.3, A.4, A.5, A.6

PLAN A.4

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
Aptos-Soquel Creek Diversions		1990	-
Diversion to Treatment Soquel		1990	-
Aptos-Soquel Treatment Plant	4 MGD	1990	163
Glenwood Reservoir	11800 Acre-ft	2005	110
Glenwood-Treatment Pipeline	4 MGD	2005	9
Aptos-Soquel Treatment Plant*	8 MGD	2005	27
			309

Plan shown in Figure D9

PLAN A.5

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
Aptos-Soquel Creek Diversions		1990	-
Diversion to Treatment Soquel		1990	-
Aptos-Soquel Treatment Plant	4 MGD	1990	163
Upper Soquel Reservoir	20400 Acre-ft	2005	172
Upper Soquel-Treatment Pipeline	7 MGD	2005	75
Aptos-Soquel Treatment Plant*	12 MGD	2005	41
			451

Plan shown in Figure D9

PLAN A.6

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
Upper Soquel Reservoir	20400 Acre-ft	1990	541
Upper Soquel-Treatment Pipeline	7 MGD	1990	32
Aptos-Soquel Treatment Plant	4 MGD	1990	163
Aptos Creek Reservoir	9000 Acre-ft	2015	24
Aptos-Treatment Pipeline	4 MGD	2015	14
Aptos-Soquel Treatment Plant*	12 MGD	2015	-
			774

Plan shown in Figure D9

PLAN P.1

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
San Felipe Pipeline	16 MGD	1980	-

Plan shown in Figure D10

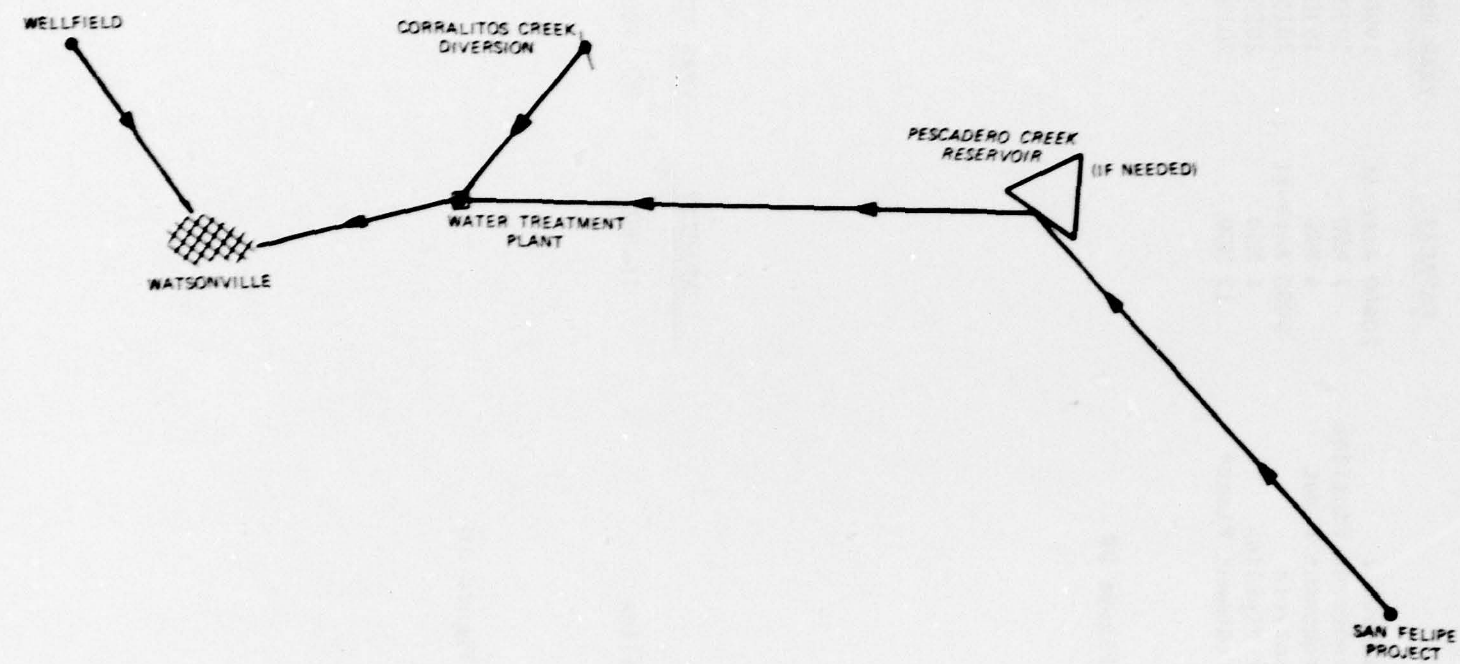


Figure D10. Plan P.1

PLAN P.2

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
Pescadero Reservoir w/o Pump	12200 Acre-ft	1980	697
Pescadero-Watsonville Pipeline	4 MGD	1980	110
Corncob Canyon Reservoir	14000 Acre-ft	1995	292
Corncob Pump Station	5 MGD	1995	46
Corncob Pipeline	5 MGD	1995	-

Plan shown in Figure D11

PLAN P.3

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
Pescadero Reservoir w/ Pump	25000 Acre-ft	1980	1285
Pajaro-Pescadero Pump Station	20 MGD	1980	161
Pescadero-Watsonville Pipeline	10 MGD	1980	27
Pajaro-Pescadero Pipeline	20 MGD	1980	75
			1548

Plan shown in Figure D12

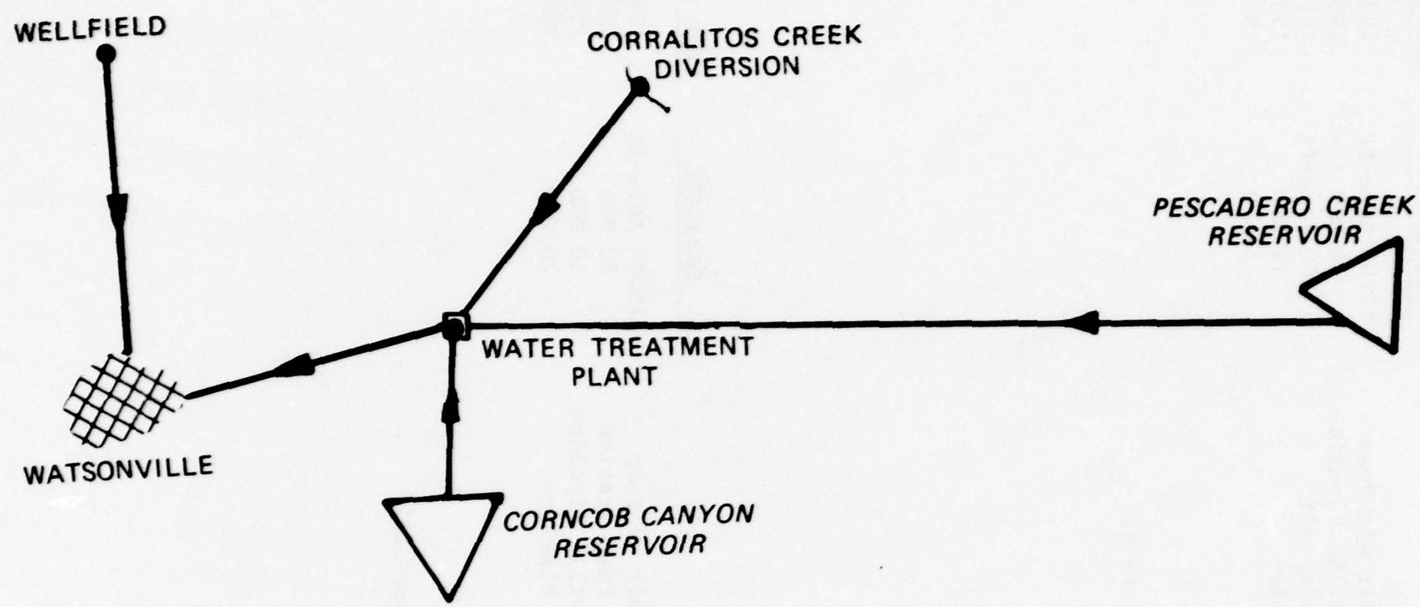


Figure D11. Plan P.2

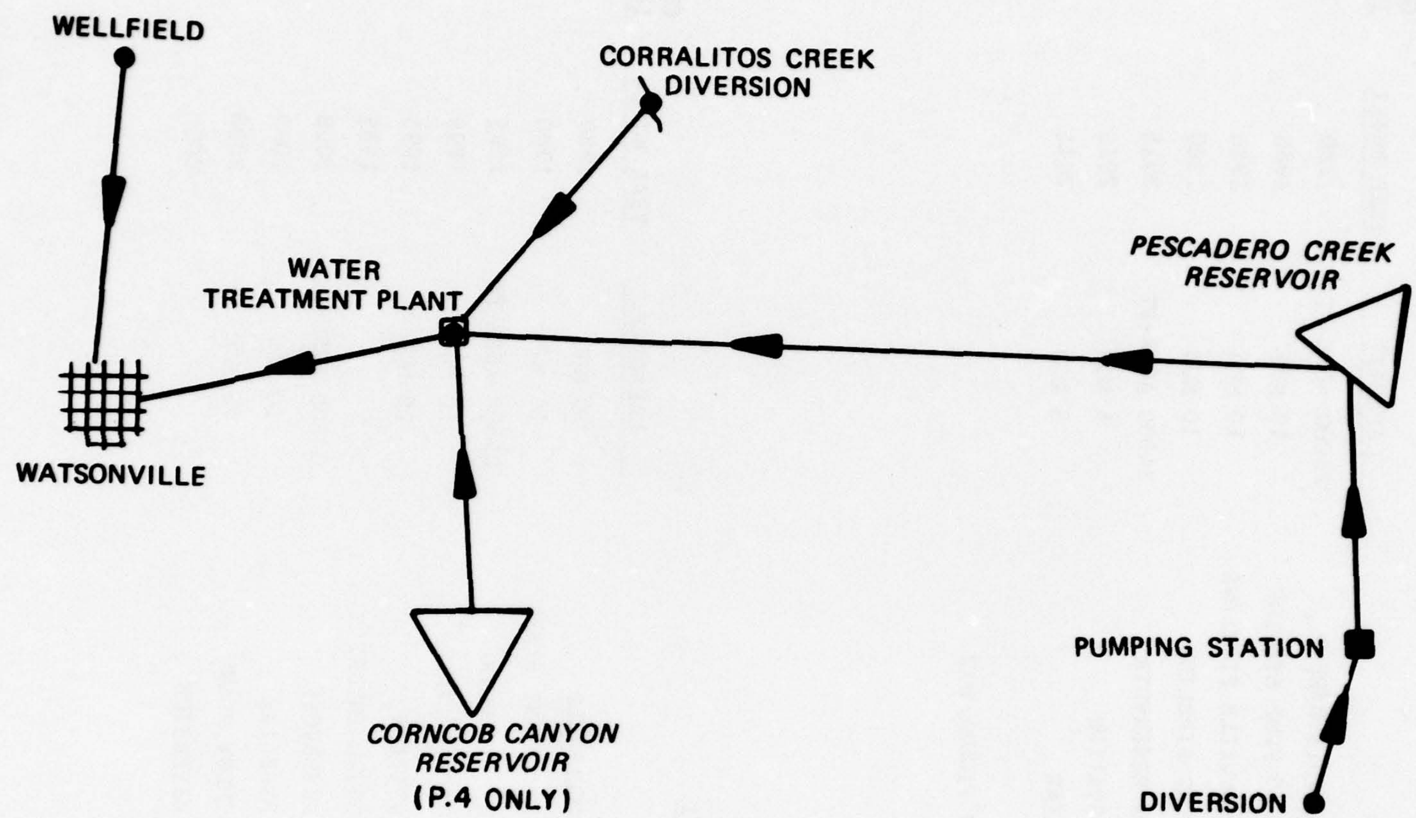


Figure D12. Plans P.3, P.4

PLAN P.4

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
PESCADERO RESERVOIR W/PUMP	25000 ACRE-FT	1980	1285
PAJARO-PESCADERO PUMP STATION	10 MGD	1980	161
PESCADERO-WATSONVILLE PIPELINE	10 MGD	1980	27
PAJARO-PESCADERO PIPELINE	10 MGD	1980	75
CORNCOB CANYON RESERVOIR	14000 ACRE-FT	2015	34
CORNCOB PUMP STATION	5 MGD	2015	6
CORNCOB PIPELINE	5 MGD	2015	3
			1591

PLAN SHOWN IN FIGURE D12

PLAN SA.1

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1995	481
ZAYANTE-FELTON PIPELINE	10 MGD	1995	37
FELTON PUMP STATION	20 MGD	1995	85
SANTA CRUZ-SOQUEL INTERTIE		1995	--
SCOTT CREEK RESERVOIR	32800 ACRE-FT	2008	182
NORTH COAST PIPELINE	10 MGD	2008	52
GORDOLA TREATMENT PLANT	10 MGD	2008	72
SAN VICENTE DIVERSION		2008	5
			1140

PLAN SA.2

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1995	481
ZAYANTE-FELTON PIPELINE	10 MGD	1995	37
FELTON PUMP STATION	20 MGD	1995	85
SANTA CRUZ-SOQUEL INTERTIE		1995	--
SCOTT CREEK RESERVOIR	32800 ACRE-FT	2008	182
NORTH COAST PIPELINE	10 MGD	2008	52
GORDOLA TREATMENT PLANT	10 MGD	2008	72
SAN VICENTE DIVERSION		2008	5
GLENWOOD RESERVOIR	11800 ACRE-FT	2018	12
GLENWOOD-TREATMENT PIPELINE	4 MGD	2018	5
APTOS-SOQUEL TREATMENT PLANT	4 MGD	2018	5
			1162

PLAN SA.3

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1995	481
ZAYANTE-FELTON PIPELINE	10 MGD	1995	37
FELTON PUMP STATION*	20 MGD	1995	85
FELTON TREATMENT PLANT	5MGD	1995	139
SANTA CRUZ-SOQUEL INTERTIE		1995	-
GLENWOOD RESERVOIR	11800 ACRE-FT	2008	12
GLENWOOD-TREATMENT PIPELINE	4 MGD	2008	5
APTOS-SOQUEL TREATMENT PLANT	4 MGD	2008	5
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2015	62
NORTH COAST PIPELINE	10 MGD	2015	10
GORDOLA TREATMENT PLANT	10 MGD	2015	27
			1089

PLAN SA.4

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1995	579
NORTH COAST PIPELINE	10 MGD	1995	134
GORODOLA TREATMENT PLANT	10 MGD	1995	239
SAN VICENTE DIVERSION		1995	18
SANTA CRUZ-SOQUEL INTERTIE		1995	-
FELTON TREATMENT PLANT	5 MGD	1995	139
GLENWOOD RESERVOIR	11800 ACRE-FT	2012	47
GLENWOOD-TREATMENT PIPELINE	4 MGD	2012	21
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2018	25
GORDOLA TREATMENT PLANT*	20 MGD	2018	7
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2018	7
BALDWIN GORDOLA PIPELINE	5 MGD	2018	1
			1443

PLAN SA.5

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1995	579
NORTH COAST PIPELINE	10 MGD	1995	134
GORDOLA TREATMENT PLANT	10 MGD	1995	239
SAN VICENTE DIVERSION		1995	18
SANTA CRUZ-SOQUEL INTERTIE		1995	-
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2012	98
GORDOLA TREATMENT PLANT*	20 MGD	2012	30
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2012	29
BALDWIN GORDOLA PIPELINE			1
			1354

PLAN SA.6

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
SCOTT CREEK RESERVOIR	32800 ACRE-FT	1995	579
NORTH COAST PIPELINE	10 MGD	1995	-
GORDOLA TREATMENT PLANT	10 MGD	1995	239
SAN VICENTE DIVERSION		1995	18
UPPER SOQUEL RESERVOIR	20400 ACRE-FT	2012	74
UPPER SOQUEL-TREATMENT PIPELINE	7 MGD	2012	32
APTOS-SOQUEL TREATMENT PLANT	4 MGD	2012	21
			1189

PLAN SA.7

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
GLENWOOD RESERVOIR	11800 ACRE-FT	1995	253
GLENWOOD-TREATMENT PIPELINE	4 MGD	1995	21
APTOS-SOQUEL TREATMENT PLANT	4 MGD	1995	118
SANTA CRUZ-SOQUEL INTERTIE		1995	-
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2003	296
NORTH COAST PIPELINE	10 MGD	2003	44
GORDOLA TREATMENT PLANT	10 MGD	2003	118
GORDOLA TREATMENT PLANT*	20 MGD	2017	11
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2017	11
BALDWIN GORDOLA PIPELINE	5 MGD	2017	2
			1100

PLAN SA.8

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
GLENWOOD RESERVOIR	11800 ACRE-FT	1995	253
GLENWOOD-TREATMENT PIPELINE	4 MGD	1995	21
SANTA CRUZ-SOQUEL INTERTIE		1995	118
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2003	273
NORTH COAST PIPELINE	10 MGD	2003	44
GORDOLA TREATMENT PLANT	10 MGD	2003	118
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	2017	12
UPPER SAN LORENZO PLANT	5 MGD	2017	9
			1074

PLAN SA.9

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
UPPER SOQUEL RESERVOIR	20400 ACRE-FT	1995	397
UPPER SOQUEL-TREATMENT PIPELINE	4 MGD	1995	22
APTOS-SOQUEL TREATMENT PLANT	4 MGD	1995	118
SANTA CRUZ-SOQUEL INTERTIE		1995	-
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2006	209
NORTH COAST PIPELINE	10 MGD	2006	27
GORDOLA TREATMENT PLANT	10 MGD	2006	102
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	2018	8
UPPER SAN LORENZO PLANT	5 MGD	2018	6
			1115

PLAN SA.10

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
GORDOLA TREATMENT PLANT	10 MGD	1995	239
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	1995	155
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	1995	177
UPPER SAN LORENZO PLANT	5 MGD	1995	139
SANTA CRUZ-SOQUEL INTERTIE		1995	--
KINGS CREEK RESERVOIR	8000 ACRE-FT	2003	94
BEAR CREEK RESERVOIR	12800 ACRE-FT	2007	95
BOULDER CREEK RESERVOIR	10200 ACRE-FT	2013	58
BEAR CREEK-FELTON PIPELINE	5 MGD	2007	12
FELTON-GRAHAM HILL PIPELINE	5 MGD	2007	11
			1206

PLAN SAP.1

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	1990	657
ZAYANTE-FELTON PIPELINE	10 MGD	1990	50
FELTON PUMP STATION	10 MGD	1990	118
FELTON TREATMENT PLANT	5 MGD	1990	184
SANTA CRUZ-SOQUEL INTERTIE		1990	--
WATSONVILLE-SOQUEL INTERTIE		1990	--
SCOTT CREEK RESERVOIR	32800 ACRE-FT	2000	368
NORTH COAST PIPELINE	10 MGD	2000	42
GORDOLA TREATMENT PLANT	10 MGD	2000	176
SAN VICENTE DIVERSION		2000	25
GLENWOOD RESERVOIR	11800 ACRE-FT	2012	47
GLENWOOD-TREATMENT PIPELINE	4 MGD	2012	11
APTOS-SOQUEL TREATMENT PLANT	4 MGD	2017	21
WADDELL CREEK RESERVOIR	28800 ACRE-FT	2017	37
GORDOLA TREATMENT PLANT	20 MGD	2017	11

(continued)

PLAN SAP.1 (concluded)

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2017	11
BALDWIN GORDOLA PIPELINE	5 MGD	2017	1
			1985

PLAN SAP.2

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
SANTA CRUZ-SOQUEL INTERTIE		1990	--
WATSONVILLE-SOQUEL INTERTIE		1990	--
SAN FELIPE PIPELINE	16 MGD	1990	--
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	2008	151
ZAYANTE-FELTON PIPELINE	10 MGD	2008	11
FELTON PUMP STATION	20 MGD	2008	26
FELTON TREATMENT PLANT	5 MGD	2008	42
SCOTT CREEK RESERVOIR	32800 ACRE-FT	2016	228
NORTH COAST PIPELINE	10 MGD	2016	6
GORDOLA TREATMENT PLANT	10 MGD	2016	22
SAN VICENTE DIVERSION		2016	2
			714

PLAN SAP.3

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 $
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
SANTA CRUZ-SOQUEL INTERTIE		1990	--
WATSONVILLE-SOQUEL INTERTIE		1990	--
SAN FELIPE PIPELINE	16 MGD	1990	--
ZAYANTE CREEK RESERVOIR	25800 ACRE-FT	2008	151
ZAYANTE-FELTON PIPELINE	10 MGD	2008	11
FELTON PUMP STATION	20 MGD	2008	26
FELTON TREATMENT PLANT	5 MGD	2008	42
GORDOLA TREATMENT PLANT	10 MGD	2016	8
BALDWIN CREEK-GORDOLA PIPELINE	5 MGD	2016	1
BALDWIN CREEK RESERVOIR	6500 ACRE-FT	2016	22
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	2016	16
UPPER SAN LORENZO PLANT	5 MGD	2016	12
			515

PLAN SAP.4

FACILITY	CAPACITY	YEAR BUILT	COST 10^3 \$
SAN LORENZO WELLFIELD	10 MGD	1980	138
GROUNDWATER TREATMENT PLANT	10 MGD	1980	88
SANTA CRUZ-SOQUEL INTERTIE		1990	--
WATSONVILLE-SOQUEL INTERTIE		1990	--
SAN FELIPE PIPELINE	16 MGD	1990	--
SCOTT CREEK RESERVOIR	32800 ACRE-FT	2008	182
NORTH COAST PIPELINE	10 MGD	2008	20
GORDOLA TREATMENT PLANT	10 MGD	2008	72
SAN VICENTE DIVERSION		2008	5
WATERMAN SWITCH RESERVOIR	7700 ACRE-FT	2018	8
UPPER SAN LORENZO PLANT	5 MGD	2018	6
			519

APPENDIX E: RELATIONSHIP OF COST AND YEAR BUILT

1. The cost estimates for each plan are given in Appendix D, assuming that they are staged to meet the needs associated with the base population projection. If some other staging is used, the average annual costs given in Appendix D must be modified. In this appendix, the average annual cost of each facility is presented as a function of year built.

2. Water treatment facility costs are shown in Table E1, pump station costs are shown in Table E2, force main costs are shown in Table E3, and reservoir costs are shown in Table E4.

Table E1

Average Annual Cost of Water Treatment Plants

Name	Cost in 10^3 \$/Yr 1980	1990	2000	2010
Upper San Lorenzo WTP*	391	193	85	31
Felton WTP	391	193	85	31
Watsonville WTP	572	331	146	53
Aptos WTP	331	163	72	26
Gordola WTP (10 mgd)	672	331	146	54
Gordola WTP (20 mgd)	1027	505	223	82
Aptos-Soquel WTP (4 mgd)	331	163	72	26
Aptos-Soquel WTP (7 mgd)	507	250	110	40
Wellfield in San Lorenzo Valley (10 mgd)	138	68	30	11
Treatment for Groundwater (two plants at 5 mgd each)	88	44	19	7

* WTP = water treatment plant

Table E2

Average Annual Cost of Pumping Stations

Name	Cost in 10^3 \$/Yr 1980	1990	2000	2010
Pajaro-Pescadero Pumping Station	161	80	35	13
Felton Pumping Station	239	118	52	19
Corncob Pumping Station	730	64	28	11
Gordola Pumping Station	246	121	53	19
Aptos Pumping Station	252	124	55	20

Table E3

Average Annual Cost of Force Mains

Name	Cost in 10^3 \$/Yr 1980	1990	2000	2010
New Felton to Graham Hill	86	43	20	7
Waterman Switch Reservoir to Upper San Lorenzo WTP	70	35	16	6
Kings Creek Reservoir to Upper San Lorenzo WTP	40	20	9	3
Zayante Creek Reservoir to/from Felton Pumping Station	99	50	23	8
Upper Soquel Reservoir to Aptos-Soquel WTP	60	30	14	5
Glenwood Reservoir to Aptos-Soquel WTP	57	29	13	5
Aptos-Soquel WTP to Service Area	114	57	26	10
Pescadero Reservoir to Watsonville WTP	103	52	24	9
Pajaro Pumping Station to Watsonville WTP	27	13	6	2
North Coast Pipeline (Waddell Reservoir only to Gordola WTP)	231	116	54	19
North Coast Pipeline (Scott Creek Reservoir only to Gordola WTP)	183	92	42	15
North Coast Pipeline (Both Waddell and Scott Creek Reservoirs to Gordola WTP)	363	182	85	31
San Vicente Diversion to North Coast Pipeline	49	24	11	4
Baldwin Creek Reservoir to Gordola WTP	8	4	2	1
Bear Creek Reservoir to Felton Pumping Station	96	48	22	8
Aptos Creek Reservoir to Aptos-Soquel WTP	24	12	6	2
Pajaro River Diversion to Pescadero Creek Reservoir	88	33	15	5
Pajaro River to Corncob Canyon Reservoir	75	37	17	6

Table E4

Average Annual Cost of Reservoirs

Name	Cost in 10^3 \$/Yr 1980	1990	2000	2010
Waddell Creek Reservoir - Site A	1435	722	337	123
Scott Creek Reservoir - Sites A and B	1570	790	368	135
Zayante Creek Reservoir	1306	657	306	112
Waterman Switch Reservoir	479	241	112	41
Glenwood Reservoir - Site A	686	345	161	59
Upper Soquel Reservoir - Site B	1076	541	252	92
Aptos Creek Reservoir	546	275	128	47
Pescadero Creek Reservoir - w/o pumping (12,000 acre-ft)	697	351	163	60
Pescadero Creek Reservoir - w/pumping (25,000 acre-ft)	1285	647	301	110
Corncob Canyon Reservoir	791	398	186	68
Kings Creek Reservoir - Site B	497	250	116	43
Jamison Dam (Boulder Creek)	966	487	227	83
Bear Creek Reservoir	731	368	171	63
Baldwin Creek Reservoir	419	211	98	36

APPENDIX F: DESIGN AND COST PARAMETERS FOR SANTA CRUZ COUNTY

This appendix contains a great deal of data that would not be of interest to most readers of the report. A limited number of copies of this appendix are available and may be obtained by contacting:

U. S. Army Engineer Waterways Experiment Station
ATTN: Thomas M. Walski (WESEE)
P. O. Box 631
Vicksburg, Miss. 39180

Commercial telephone: 601/636-3111, Ext. 3931
FTS: 542-3931

APPENDIX G: DESIGN AND COST PARAMETERS FOR MONTEREY COUNTY

This appendix contains a great deal of data that would not be of interest to most readers of the report. A limited number of copies of this appendix are available and may be obtained by contacting:

U. S. Army Engineer Waterways Experiment Station
ATTN: Thomas M. Walski (WESEE)
P. O. Box 631
Vicksburg, Miss. 39180

Commercial telephone: 601/636-3111, Ext. 3931
FTS: 542-3931

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Walski, Thomas M
Application of MAPS to the Salinas-Monterey urban study / by Thomas M. Walski, Anthony C. Gibson. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1979.
61, [63] p. : ill. ; 27 cm. (Miscellaneous paper - U. S. Army Engineer Waterways Experiment Station ; EL-79-4)
Prepared for Office, Chief of Engineers, U. S. Army, Washington, D. C.
Appendices B, F, and G published separately.
References: p. 61.

1. Costs. 2. MAPS (Computer program). 3. Monterey County, Calif. 4. Planning. 5. Santa Cruz County, Calif. 6. Water supply. I. Gibson, Anthony C., joint author. II. United States. Army. Corps of Engineers. III. Series: United States. Waterways Experiment Station, Vicksburg, Miss. Miscellaneous paper ; EL-79-4.
TA7.W34m no.EL-79-4